BULLETIN

OF THE

SCIENTIFIC LABORATORIES

OF

DENISON UNIVERSITY

EDITED BY

FRANK CARNEY

VOLUME XVIII

1915-1916

GRANVILLE, OHIO

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EDITED BY
FRANK CARNEY
Permanent Secretary Denison Scientific Association

GRANVILLE, OHIO
December, 1915

DENISON UNIVERSITY BULLETINS   NEW SERIES NO. 58
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Clark Wells Chamberlain

The Inauguration of
Clark Wells Chamberlain, Ph. D.

As President of

Denison University

MAY, NINETEENTH AND TWENTIETH
NINETEEN HUNDRED AND FOURTEEN

EDITED BY
FRANK CARNEY
Professor of Geology and Geography

PRINTED BY
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COLUMBUS, OHIO

MCMXV

INTRODUCTION

At the meeting of the trustees held in June, 1913, Professor Clark Wells Chamberlain, head of the department of Physics of Vassar College, was elected president of Denison University. While Dr. Chamberlain was well known at home and abroad as a deep student of Physics, it was equally well known to some that he possessed administrative ability of a high order. His friends in science regretted the withdrawal of one who had already accomplished so much. The friends of Denison, and Dr. Chamberlain's former colleagues on the Denison faculty, rejoiced over the action of the trustees.

So engrossing were the duties which President Chamberlain found awaiting him that in deference to his wishes the induction ceremonies were deferred till late in the college year. This delay gave abundant time for careful preparations. All details of local arrangement were divided among the following committees, acting under the general direction of a committee appointed by the Board of Trustees:

Committee of the Board of Trustees

Herbert F. Stilwell, Chairman
Charles T. Lewis — Augustine S. Carman
Alfred D. Cole — Millard Brelsford
President C. W. Chamberlain, member ex-officio

Entertainment Committee

Millard Brelsford, Chairman
Professor C. D. Coons — Professor H. R. Hundley
Edward A. Deeds

Program Committee

Alfred D. Cole, Chairman
Augustine S. Carman — Professor Margaret Judson
Charles T. Lewis — Professor R. S. Colwell
Hon. Judson Harmon

Buildings Committee

Millard Brelsford, Chairman

Elmer E. Hopkins | Professor T. S. Johnson

Dinner Committee

Charles T. Lewis, Chairman

Associate Professor B. Spencer | Professor W. A. Chamberlin

Publicity Committee

Herbert F. Stilwell, Chairman

Professor W. H. Johnson | Assistant Professor R. W. Pence

During the month of May, Granville and its encircling hills form a most pleasing picture. The days set for the inaugural exercises were splendid, and the induction ceremonies, conducted on the South Plaza of the Campus overlooking the village and lowland framed in a vista of vari-tinted green and purple valley walls, glades and sloping pastures, were given an idyllic scene.

In harmony with nature's setting, the alumni were enthusiastic, the guests gracious, and the citizens of Granville were most generous in their hospitality. This interest of old students, of sister institutions, and of neighbors, cordially co-operating, contributed greatly to the success of the occasion.

To Professor Karl H. Eschman, A.M., of the Conservatory of Music, is due particular mention for the splendidly arranged program of music, instrumental and choral, rendered by members of the Conservatory faculty and by the College Glee Club.

On Tuesday, May 19, at two o'clock the Board of Trustees held their annual spring meeting in Cleveland Hall; and the alumni met in Recital Hall, Samuel B. Brierly, A.B., '75, President of the Alumni Association, presiding. The Carnival of Shepardson College was held at three-thirty on the Shepardson Campus. Class reunion and Club dinners were set for five-thirty. At eight o'clock, the Coburn Players presented Shakespeare's "As You Like It," the South Plaza, converted into a woodland bower, serving as a stage, and the audience occupying seats arranged on the adjacent slope of the campus. The plan was most convenient and comfortable, and the rendition of the play almost faultless.

On Wednesday morning the student body grouped in classes, the alumni, delegates, faculty, distinguished guests, and trustees, formed in academic procession in front of Stone Hall—all save the alumni and underclassmen were in academic costume — and marched to the Baptist Church for the nine o'clock chapel service. At this service Dean Richard S. Colwell, D.D., presided.

Following the chapel service, the academic procession, and friends, proceeded west along Broadway to the Cherry Street entrance of the Campus, thence to the South Plaza where the Inauguration was held. The exercises were carried out according to the arranged program.

At the conclusion of the induction ceremonies, dinner was served in the Swasey Gymnasium to distinguished guests, alumni, and faculty. Mr. Charles T. Lewis, A.B., of the Board of Trustees, was to have presided at the dinner; he was unable to be present, and another member of the Board, Rev. Herbert F. Stilwell, D.D., consented to act as master of ceremonies. The attractive menu was served with skill, reflecting the effective supervision of the committee in charge. As presiding officer, Mr. Stilwell was extremely felicitous in presenting the distinguished speakers, whose addresses formed a fitting conclusion to the academic part of the inaugural exercises.

To guests, visitors, and delegates who were interested, the college buildings were open to inspection at four o'clock. At the same time, President and Mrs. Chamberlain received visitors at the President's house. The May Festival, given by the Conservatory of Music in the Baptist Church at seven-thirty, brought to a close the two delightful days of proceedings, the inauguration of a new administration.

As a desirable addenda to this report, William Hannibal Johnson, A.B., '85, Professor of Latin, consented to prepare a brief sketch of former administrations. Among the alumni and faculty of Denison, Professor Johnson is without peer in matters pertaining to the history of the institution. We are deeply obligated to him for contributing this concise and comprehensive paper on the Presidents of Denison.

DELEGATES IN ATTENDANCE AT THE INAUGURAL

HARVARD UNIVERSITY (1636)

Wilbur Henry Siebert, A.M. .... Alumnus

YALE UNIVERSITY (1701)

John McCune, A.B. .... Alumnus

PRINCETON UNIVERSITY (1746)

Charles L. Williams, L.H.D. .... Alumnus

COLUMBIA UNIVERSITY (1754)

Rt. Rev. Theodore Irving Reese, D.D. .... Alumnus
Bishop Coadjutor of Southern Ohio

BROWN UNIVERSITY (1764)

William Herbert Perry Faunce, D.D., LL.D. .... President

RUTGERS COLLEGE (1766)

Paul Frederick Sutphen, D.D. .... Alumnus

DARTMOUTH COLLEGE (1769)

Ernest Fox Nichols, LL.D. .... President

UNIVERSITY OF VERMONT (1791)

Walter Henry Merrian, Ph.B., M.D. .... Alumnus

OHIO UNIVERSITY (1804)

Edwin W. Chubb, Litt. D. .... Dean of Liberal Arts

COLGATE UNIVERSITY (1819)

Frank C. Ewart, A.M. .... Professor

KENYON COLLEGE (1824)

George F. Weida, Ph.D. .... Professor

WESTERN RESERVE UNIVERSITY (1826)

Charles F. Thwing, D.D., LL.D. .... President

OBERLIN COLLEGE (1833)

Henry Churchill King, D.D. .... President

FRANKLIN COLLEGE (1834)

Elijah A. Hanley, D.D. .... President

MARIETTA COLLEGE (1835)

Harry Parker Ward, M.A. .... Alumnus

INDIANA STATE UNIVERSITY (1838)

O. C. Lockhart, Ph.D. .... Alumnus

OHIO WESLEYAN UNIVERSITY (1842)

Herbert Welch, D.D. .... President

WITTENBERG COLLEGE (1845)

Charles G. Heckert, D.D. .... President

BUCKNELL UNIVERSITY (1846)

John H. Harris, LL.D. .... President

BELOIT COLLEGE (1846)

Irving S. Kull, A.M. .... Alumnus

OTTERBEIN UNIVERSITY (1847)

Walter C. Clippinger, A.B. .... President

UNIVERSITY OF ROCHESTER (1850)

Rush Rhees, D.D. .... President

ROCHESTER THEOLOGICAL SEMINARY (1850)

George Cross, D.D. .... Professor

HEIDELBERG UNIVERSITY (1850)

Francis W. Kennedy, A.M., D.B. .... Professor

NORTHWESTERN UNIVERSITY (1851)

D. B. Rawlins, Ph.B. .... Alumnus

WASHINGTON UNIVERSITY (1853)

Anna C. Mills, A.B. .... Alumna

BEREA COLLEGE (1855)

William Goodell Frost, Ph.B., D.D. .... President

MT. UNION COLLEGE (1856)

Walter Gingery, A.B. .... Alumnus

BAKER UNIVERSITY (1858)

E. A. Riley, A.B. .... Alumnus

MASSACHUSETTS INSTITUTE OF TECHNOLOGY (1861)

Richard Cockburn Maclaurin, ScD., LL.D. .... President

VASSAR COLLEGE (1861)

Marietta B. Knight, A.B. .... Alumna

UNIVERSITY OF MAINE (1862)

G. G. Barker, A.B. .... Alumnus

BATES COLLEGE (1863)

Malcolm E. Stickney, A.M. .... Alumnus

CORNELL UNIVERSITY (1865)

Frank Carney, Ph.D. .... Alumnus

UNIVERSITY OF WOOSTER (1866)

Louis E. Holden, D.D. .... President

UNIVERSITY OF MINNESOTA (1869)

J. H. Gill, M.E. .... Alumnus

STEVENS INSTITUTE OF TECHNOLOGY (1870)

W. T. Magruder, M.E. .... Alumnus

OHIO STATE UNIVERSITY (1870)

William Oxley Thompson, LL.D. .... President
Homer C. Price, Ph.D. .... Professor
H. C. Ramsower, M.S. .... Professor

UNIVERSITY OF CINCINNATI (1870)

Harris Hancock, Ph.D. .... Professor

UNIVERSITY OF AKRON (1870)

O. E. Olin, Ph.D..........Professor

WELLESLEY COLLEGE (1875)

Anna B. Peckham, A.M..........Alumna

JOHNS HOPKINS UNIVERSITY (1876)

Benjamin L. Bowen, Ph.D..........Alumnus

UNIVERSITY OF TEXAS (1883)

Warren E. Bigoney, LL.B..........Alumnus

MECHANICS INSTITUTE OF ROCHESTER (1884)

Jesse E. Woodland, M.S..........Professor

CASE SCHOOL OF APPLIED SCIENCE (1889)

Charles S. Howe, Ph.D..........President

UNIVERSITY OF CHICAGO (1892)

Frank Justus Miller, LL.D..........Professor

Ernest D. Burton, LL.D..........Professor

UNIVERSITY OF OKLAHOMA (1892)

C. Marsh, A.B..........Alumnus

CARNEGIE INSTITUTE OF TECHNOLOGY (1905)

Frank Parker Day, M.A..........Director

RICE INSTITUTE

E. O. Lovett, Ph.D..........President

AMERICAN MATHEMATICAL SOCIETY

Harris Hancock, Ph.D..........Professor in University of Cincinnati

AMERICAN PHYSICAL SOCIETY

Alfred Dodge Cole, A.M..........Secretary

EDUCATION BOARD, Northern Baptist Convention

Frank W. Padelford, D.D.

WAYLAND ACADEMY

Rev. Vernon S. Phillips, A.B..........Alumnus

THE INAUGURATION OF
CLARK WELLS CHAMBERLAIN, Ph. D.
AS
PRESIDENT OF DENISON UNIVERSITY

TUESDAY AFTERNOON, MAY 19

At Two O'Clock

Meeting of the Trustees in Cleveland Hall
Meeting of the Alumni in Recital Hall
Samuel B. Brierly, A.B., '75,
President of the Alumni Association, Presiding

At Three-Thirty O'Clock

Shepardson College Carnival on Shepardson Campus

At Five-Thirty O'Clock

Class and Club Dinners

At Eight O'Clock

The Coburn Players: Shakespeare's "As You Like It"
Denison Campus, South Plaza

WEDNESDAY MORNING, MAY 20

At Nine O'Clock

I. MORNING CHAPEL SERVICE

In charge of Dean Richard S. Colwell, D.D., Professor of the Greek Language and Literature, since 1877 Acting President 1912-13

Processional—Elizabeth M. Benedict, College Organist

Chant by the Congregation

Scripture Reading

Anthem

"The Heavens Are Telling" .... *Haydn*

The College Choir

National Hymn (Number 827)

PRAYER, closing with the Lord's Prayer
RECESSIONAL—W. F. Chamberlin, A.B., '93

At Ten O'Clock

II. THE INAUGURATION, on the campus

THE COLLEGE SONG, led by the College Choir
"Denison"..*V. E. Field*, '03

INVOCATION
President Elijah Andrews Hanley, A.M., D.D.

THE INDUCTION AND PRESENTATION OF THE CHARTER
George Moore Peters, LL.D., '67
President of the Board of Trustees

THE ACCEPTANCE
The President of the University

RECITAL OF NAMES OF DELEGATES AND GUESTS IN ATTENDANCE
Willis Arden Chamberlin, Ph.D., Professor of the German Language and Literature

THE SHEPARDSON GLEE CLUB
"The Windy Winter From the Sky Is Gone"..*Horatio Parker*

SPEECHES OF CONGRATULATION
In behalf of the Delegates
William Herbert Perry Faunce, D.D., LL.D.
President of Brown University
In behalf of the Faculty
Charles Luther Williams, L.H.D.
Professor of Rhetoric and English Literature
In behalf of the Alumni
Ernest DeWitt Burton, A.B., '76
Head Professor New Testament Literature and Exegesis, University of Chicago
In behalf of the Undergraduates of Granville College
George DeArmond Curtin
President of the Senior Class
In behalf of the Undergraduates of Shepardson College
Marjorie Lea McCutcheon
President Shepardson College Student Association

THE PRESIDENT'S INAUGURAL ADDRESS

THE DENISON GLEE CLUB
"Invictus"..*Bruno Huhn*
THE CONFERRING OF DEGREES
William Herbert Perry Faunce
President of Brown University (1764)
Presented by Richard S. Colwell, D.D.
Ernest Fox Nichols
President of Dartmouth College (1769)
Presented by Professor Alfred D. Cole, A.B., Trustee
Richard Cockburn MacLaurin
President of Massachusetts Institute of Technology (1861)
Presented by Professor Frank Carney, Ph.D.
COLLEGE SONG
"Granville"..................................*F. W. Shepardson, A.B.*, '82
Led by the College Choir.
BENEDICTION
Rev. Herbert Fenton Stilwell, D.D., Trustee

At One O'Clock

III. DINNER to Distinguished Guests, Alumni and Faculty, given in Swasey Gymnasium by the Trustees
PRESIDING OFFICER—Charles T. Lewis, Esq., A.B.
Of the Board of Trustees
SPEAKERS
President Ernest Fox Nichols, LL.D., of Dartmouth College
President Henry Churchill King, D.D., of Oberlin College
President Charles Franklin Thwing, LL.D., of Western Reserve University
President William Oxley Thompson, LL.D., of Ohio State University

At Four O'Clock

IV. INSPECTION OF COLLEGE BUILDINGS

V. PRESIDENT AND MRS. CHAMBERLAIN AT HOME
The President's House

At Seven-Thirty O'Clock

VI. THE MAY FESTIVAL

MORNING CHAPEL SERVICES IN THE BAPTIST CHURCH

Dean Richard Steere Colwell, D.D., Professor of the Greek Language and Literature, presided at the chapel exercises which were conducted in the Baptist Church at nine o'clock. Dean Colwell graduated from Brown University in the class of 1870; he came to Denison as Professor of Greek in 1877, and has since served the institution continuously as professor, dean, or acting president, a devoted and able service.

The order of service was as follows:

PROCESSIONAL—Elizabeth M. Benedict, College Organist

CHANT BY THE CONGREGATION

SCRIPTURE READING

ANTHEM—The College Choir

"The Heavens Are Telling" .... *Haydn*

NATIONAL HYMN

God of our fathers, whose almighty hand
Leads forth in beauty all the starry band
Of shining worlds in splendor through the skies,
Our grateful songs before Thy throne arise.

Thy love divine hath led us in the past,
In this free land our lot by Thee is cast;
Be Thou our ruler, guardian, guide and stay,
Thy word our law, Thy paths our chosen way.

From war's alarms, from deadly pestilence,
Be Thy strong arm our ever sure defence;
Thy true religion in our hearts increase,
Thy bounteous goodness nourish us in peace.

Refresh Thy people on their toilsome way,
Lead us from night to never ending day;
Fill all our lives with love and grace divine,
And glory, laud, and praise be ever Thine.

PRAYER, closing with the Lord's Prayer—Dean Colwell

Almighty God, our Heavenly Father, we thank Thee for the blessings of the life which now is and for the hopes of that which is to come. Help us to use and enjoy the one in Thy fear and to look forward in devout confidence to glorious fulfillment of the other.

We thank Thee for a Christian college and all the blessings that accompany it. We thank Thee that sturdy men of God in the days that are gone were moved by Thy Spirit to lay in this community the foundations of a Christian school. We bless Thee for the lives which they lived, the tasks which they performed so well, and for the foundation which they laid. We are grateful to Thee that they possessed the wisdom to look forward into the future and to see the need which was sure to come for the Christian education of young people. We thank Thee that with confidence in Thy word and faith in Thy truth they laid foundations deep and strong, upon which in the years that followed there could be builded an institution which should do faithful work for Thy cause and kingdom in preparing young people for their life work in the fear of God. We thank Thee that their work has gone out into all the earth, and that in this nation and in many nations there are to be found many who, trained here in the nurture and admonition of the Lord, are serving Thee and their generation with greater efficiency because of that training.

We bless Thee for the glorious influence for righteousness, for God and the truth, which has emanated so broadly from this institution; and we are grateful that we, the successors of these servants of Thine who labored here in past years, are permitted to have our small part in the accomplishment of Thy work in the world. Help us to remember that Thine eye is upon us, and that Thou art ready to supplement our deficiencies and grant us all needed grace that we may accomplish our tasks in a way which will meet with Thine approval. Help us to recognize our need and Thy sufficiency, that we may be of a teachable spirit as well as filled with a Godly zeal. Grant us Thy guidance without which all efforts of man must fail.

And give us, O God, as we look out into the future great faith in Thee and the power of Thy truth. Gird us with Thy

might, and as there comes up before us a great vision of the great work which must be done in time to come for God and humanity may there come a still greater vision of Thy power and wisdom. May our eyes be opened like those of the servant of the prophet Elisha in the days of old, and may we see that "they which be with us are more than they that be against us."

We pray that in all time to come this college may be a fountain of righteousness; that it may be a seat of sound learning, of Christian learning. May its President and Faculty be men who recognize that in studying the laws of mind and of matter they are studying the expression of the will of "God the Father Almightly, the Maker of heaven and earth"; and may the men and the women who shall in time to come go out from these halls be men and women who shall recognize that the fear of the Lord is the beginning of wisdom, and that the noblest life that mortal man can live is that which is patterned after the life of "the man of Galilee."

Bless, we pray Thee, the benefactors, trustees, the teachers, the students of this college, those of the past, of the present and of the time to come, and make them all to be efficient servants of the Lord Jesus Christ, in whose name we pray, and graciously hear us as we say from our hearts

RECESSIONAL—William Fosdick Chamberlin, B.S., '93

At the conclusion of the Chapel service, the delegates and invited guests, together with the trustees, officers, faculty, alumni and undergraduates of the colleges formed in academic procession, under the escort of the Senior class, and proceeded to the South Plaza of the campus, where the inauguration exercises were held.

THE INAUGURATION ON THE SOUTH PLAZA

Led by the College Choir, the audience standing joined in singing:

"Denison"..*Vinton Ernest Field, A.B.*, '03

To Denison, we raise our song,
  Fair college on the hill,
The name that sets our souls on fire,
  And makes our senses thrill.
To Denison, my Denison,
  In praise our voices swell,
The scenes of happy college days,
  The Home we love so well.

Oh morning glow, which guilds the east,
  Oh sun which shines at noon,
Oh stars which bloom at eventide,
  Oh radiant glowing moon,
Look from the pathless, azure dome,
  Shed blessings from above,
On college halls and college walls,
  The Denison we love.

And when the shadows softly fall,
  O'er hills and valleys dear,
Across the college campus rings
  The melody so clear;
The circling hills throw back again
  The glad inspiring song,
And in our hearts to Denison,
  Our praises we prolong.

When from the fold we far shall stray,
  With souls no longer young,
We'll ne'er forget our college days,
  These happy scenes among;

And when our steps have feeble grown,
  Our journey almost done,
E'en then with fleeting breath we'll praise
  Our dear Old Denison.

INVOCATION

The invocation, by the Reverend Elijah Andrews Hanley, A.M., D.D., President of Franklin College, was as follows:

O God, we would lift our hearts to Thee in glad recognition of Thy goodness and wonderful works to the children of men. This place and occasion with all the sacred interests which concern us here are gifts of Thy wisdom and love. Thine is this beautiful world, the mind of man and the hope of life everlasting. Thou givest unto us to think Thy thoughts after Thee and to have part in the accomplishment of Thy purposes.

We thank Thee, O Lord, for the Kingdom of Truth which is slowly coming in all the earth. We thank Thee for every seeker after light; for the patient devotion of the scientist, for the vision of poet and prophet, for illumined souls, interpreters of Thy ways unto men. We thank Thee for that great company of youth in our land who are giving themselves to the pursuit of knowledge. We thank Thee for institutions dedicated to learning and for all who would enlighten and guide the coming generations.

Let Thy blessings, we pray Thee, rest upon Denison University. We would rejoice in her noble history, in her founders, teachers, officers; and in that goodly company in this land and throughout the earth who received their inspiration in these halls. May the work of the past be a promise of mighty achievement in the future. As college generations come and go, may the spirit of eager youth be possessed by reverence and quickened by the energy of God. May thought be true, work be faithful and all the surrounding influences of life be sweet and wholesome. And may Jesus Christ be exalted as the teacher of life and Savior of the world.

Let Thy favor, O God, be with Thy servant, the President of this university. Gird him with sufficient strength, grant unto him needed wisdom, and enable him to live with wonder before the power and worth of human personality. May he

have the gift of understanding the heart of youth. Surround him by a faculty who love knowledge for men's sake, and support him by Trustees who shall cherish their responsibility as a sacred trust. Raise up friends who shall give of their means to strengthen and support this work. Unto President, officer, teacher and student may the vision of life shine forth with unfading glory.

May Thy benediction, O God, rest upon the sister institutions represented here today and upon every seat of learning in our land and in all the earth. We thank Thee for the fellowship of inquiring minds, for the brotherhood of those who love truth more than earthly treasure. May the calling of the teacher be highly exalted and may the future citizens of the Republic learn in order that they may be servants of God and of the people. Let truth prevail and ignorance flee away. Cast down the reign of hatred and error and speed the day when man to man the world o'er shall brothers be. And at last may the knowledge of the Lord illumine every land and may Thy kingdom come and Thy will be done in earth as it is done in heaven. Amen.

THE INDUCTION AND PRESENTATION OF THE CHARTER.

After the invocation, George Moore Peters, LL.D., '67, in behalf of the Trustees of Denison University, thus addressed the President-elect:

DR. CLARK WELLS CHAMBERLAIN: It is with great pleasure we have come at last formally and publicly to recognize you as the President of Denison University, and to confer on you all the honors, titles and emoluments of the office. We might, perhaps, come to you with profounder reverence, did you present us with an abundance of gray locks. But we are quite content that your head is shingled o'er with black, for it is an indication of a strong and vigorous young manhood, and gives promise of many years of active and successful service.

This is not the first time we have met you. It has not been many years since you climbed these hills, and walked to and fro in these halls, a quiet and earnest student in honest search of knowledge. You passed through the University with honors to

yourself and to the college. You went forth into the world to the work of a teacher, but we kept our eyes upon you, and it was not long before we had you back among us as one of our honored professors, delighting us with your wide-awake, magnificent qualities as instructor. In your spare moments you were much engaged in investigations of an original character. By your own eagerness you were industriously employed in digging into the fields of physics, striving to discover new facts by which you might make plain some of the hitherto unsolved problems which had caused perplexity to many a hard working student. So successful was your work, that it was not long before you became

known on both sides of the Atlantic, and other colleges were beginning eagerly to inquire about you.

Again you went away from us, for several years. You were active in other parts of the educational world winning to yourself degrees and honors. But the Board of Trustees had their eyes upon you still, and when the chair of President was made vacant by the resignation of Dr. Emory W. Hunt, turned at once to you. They felt that they now had a position to offer you commensurate with your abilities. They knew you loved your Alma Mater, and would surely give her first consideration. They were not a little chagrined, however, at the quietness and coolness with which you received their communication. You expressed great

appreciation of the honor conferred upon you by the election, but you quietly pocketed the letter conveying it, stepped aboard a steamer, and sailed for Europe, remarking that we might expect to hear from you later. All the summer we waited, anxiously waited, still no answer. It came time for the new year to open. We were thinking of making arrangements for a President pro-tem, when word came that you had landed in New York, and almost at once a letter was received announcing your hearty acceptance of the appointment. Our fears were dispelled.

The lateness of your arrival, together with the many new and important questions demanding your attention, because it was already proving to be for the University a transitional period, made it quite impossible to give thought to the inaugural ceremonies which were early determined upon by the Trustees.

You said, "Let things go for the present. In the spring we we may be able to carry them out." And so we are here today, this beautiful, God-given May day, we, your Trustees, all connected with these schools, your neighbors and friends, these distinguished educators from various parts of the country—all of us have come together to give you greeting, to rejoice with you on this auspicious occasion, and to congratulate the University in its rare good fortune.

Dr. Chamberlain, I have been requested by the Committee of Arrangements to present you with the Charter of the University. I promptly accepted the appointment, for the Committee gave me no opportunity to say no, and then I wished to have some post in the joyous ceremonies. The ancient engrossed copy was reduced to ashes in the great fire of 1905, which destroyed all the laboratories of the college. There was preserved, however, among the records of the college a copy of the old charter. I had it engrossed anew, and will present it to you in the roll which I hold in my hand. I was not a little surprised to find how accurately we had been quoting and adhering to that old charter during all these years. It proved to me that there had been a time when it had been carefully cherished and stored up in the memory of the fathers, and had been handed down to the younger generations of Trustees with no deviations from year to year. And so had the younger men carefully treasured it up that it required no reference to the old original word in order to settle any disputes that might arise. It was better, stronger and more

enduring because of this, than if it had been engraved on tablets of bronze and exposed to the noon day sun.

I was very glad of one thing. This old copy brought again to light the names of the men who had banded together in the year 1867, in accordance with the new requirements of the State, to found anew and confirm what had already been done in the erection of this institution of higher learning. A glance at those names would seem to show that it had been well, wisely, and nobly founded. The list contained such names as Sampson Talbot, Marsena Stone, Judges Ewart, Hoyt and Bishop, E. E. Barney, E. Thresher, and others very like them. They were

some of the wisest, noblest and most God-fearing men of this State, and I will venture to say of any state in this Union. They have all passed away save one, Dr. Henry F. Colby, so long pastor of the First Baptist Church of Dayton. Already he is near the point of death. At the time he penned his name he was young, very young for one occupying so important a position. Would that he could be with us today to present the copy of the Charter which originally bore his name. Our cup of joy would then be full. Another of those honored names was that of Mr. E. M. Downer, long an honored resident of this village. He passed away only two or three weeks since.

So, Mr. President, you will understand that this is not an original. It is only a copy, but most assuredly a correct copy, with many of the most sacred signs upon it. The Charter of which this is a copy, was the sixth in the line of Charters. It was written in 1867. Those first years, say from 1833 to 1870, formed a very transitional period in the history of the state. The laws of the state were almost constantly changing, and this was particularly true concerning those having to do with education. There was much uncertainty as to what was fitting and right and how schools should be governed and maintained, especially those of a benevolent nature, and so there had to be many changes at first to keep within state requirements. The period named was also very transitional in the history of our institution. We began our life with the old name Granville Literary and Theological Institution. We continued under that name for some years, later changing to Granville College, and finally, about the year 1850, to Denison University, to commemorate the name of the largest giver at that time. It was at this time we changed the location from a mile west on the Columbus road to this beautiful spot, and began erecting these new buildings. We began as an Agricultural College, but this proving a failure, we here launched out as a college pure and simple, and so have continued since with good success. And you see we have passed through many changes. But for the past fifty years, as represented by this Charter, we have remained practically the same.

There are some, who consider themselves friends, who regard this Charter as entirely too antiquated. They say it is musty with age, that it bears the stains of antiquity. We need, they say, something more up-to-date. And yet we are not very unlike many of the best colleges of our day, the very ones most frequently quoted by these so-called friends, for instance, our aged sisters, Harvard and Yale. They have charters running back to the Colonial days, and they are very proud of them, insisting that no changes be made. It may be well occasionally to pass new enactments to suit new laws of the state, or to define the meaning in some particular of the old Charter, or to make its original intent more effective. But that there should be anything like an uprooting of the old, or a displacing of parts by an expression of entirely new intent would seem never to be wise or essential. Mere whims or fancies pertaining to methods of instruction or

methods of government are no good excuse for change of fundamental laws. Education is a thing of permanent character. It is much like the eternal word and has to do with eternal verities in their application to the mind and heart of man which are essentially the same in every age. And the more we think of education as immutable in its bearing and demands the more shall we prize its value, and be benefitted by the operation of its principles.

Some of these objectors think our charter should be changed in order that it may free itself from all charges of sectarianism, because it insists that this shall be a Baptist college and be true

to its Baptist affiliations. But it insists upon this, that the institution may be bound to a denomination, which shall furnish for it a standard, which shall be under obligation to care for it and give to its support and definite control. Denominationalism is not necessarily sectarianism. Harvard, Yale, Princeton are so strongly denominational as to have theological departments, where are taught doctrines in harmony with their fundamental laws. But who ever thought of these schools as sectarian, or bigoted in their spirit and attitude? I have been intimately acquainted with Denison University for more than fifty years, and I have yet to see the slightest indication of sectarian narrowness, or bigotry in any of its spirit, teaching or forms of government.

It has no theological department, it insists on no articles of faith, it excludes no class from its benefits. True education is the building up not only of mind, but also and preeminently of character, and you cannot rightly impart education without you have some guiding principles, some absolute convictions. You cannot rightly tone up the mind or strengthen the character without imparting some right conceptions of God and His Christ.

Some have found fault with our Charter because it requires our Trustees to be chosen from men residing within the boundaries of the State of Ohio. This was wise originally and it is wise today. This College was founded at the outset for the special benefit of young men residing in this general locality and who, if they desired the advantages of a higher education, must take the long and tiresome journey beyond the Alleghanies, then untracked by steel rails and knowing nothing of lightning speeds. But permanently, there is a strong sense in which the College is for the State, and the State for the College. Men should be chosen to administer its affairs who have a local knowledge and a local interest. It must be remembered, too, that this is a State of boundaries scarcely less in dimensions than those of a great kingdom, having a great circle of men of many minds, and possessing interests wide and large. If we were a little state like Rhode Island we should perhaps go beyond our limit to find men of sufficient quality and variety of intellect. I once heard Dr. A. C. Kendrick, of Rochester, N. Y., speaking on this very point, say somewhat amusingly, "Little Rhode! Why, it is so small that when they would build a railroad they would have to build it narrow gauge in order to get both rails within the State." I am quite certain they would have to attempt something similar were they to try to build a college for the special benefit of the State.

So, Mr. President, I present you this Charter feeling assured that you will find it sufficiently adequate for all your purposes in assuming command of this great work. We trust you will remember the noble men who framed it, and be inspired by their example. We love you, and believe in you. We have great hopes of you, and pray that God's blessing may be upon you and that you may be greatly strengthened by Him for your arduous undertaking.

THE ACCEPTANCE

In accepting the charter, the President of the University said:

DR. PETERS: In accepting this time honored Charter from the hands of one who has spent fifty years in the service of Alma Mater, I realize that a sacred trust has passed into my keeping. Humbly, as one who understands the magnitude of the task assigned, I accept the charge committed to my care. Loyally, as becomes a son of Denison, I undertake the duty assigned. Hopefully, as one who believes in the future of Christian Education, I pledge my service. Reverently, as one who recognizes the Christian foundations established here, I state my purpose to devote my best powers to the services of these colleges, and pray that God may grant me strength, wisdom and courage to do my work faithfully and well.

RECITAL OF THE NAMES OF DELEGATES AND GUESTS IN ATTENDANCE

Following the acceptance of the charter, Professor Willis Arden Chamberlin, A.M., Ph.D., Professor of the German Language and Literature, read the names of delegates and guests in attendance.

SINGING BY THE SHEPARDSON GLEE CLUB

"The Windy Winter From the Sky Is Gone"........*Horatio Parker*

SPEECHES OF CONGRATULATION

After the singing, the following speakers delivered addresses of congratulation:

In behalf of the Delegates
William Herbert Perry Faunce, D.D., LL.D.
President of Brown University

In behalf of the Faculty
Charles Luther Williams, A.M., L.H.D.
Professor of Rhetoric and English Literature

In behalf of the Alumni
Ernest DeWitt Burton, A.B., D.D., class of 1876
Head Professor New Testament Literature and Exegesis
University of Chicago

In behalf of the Undergraduates of Granville College
George DeArmond Curtin, President of the Class of 1914

In behalf of the Undergraduates of Shepardson College
Marjorie Lea McCutcheon, President of Shepardson College Student Association.

Their addresses follow in the order of delivery, except that of Professor Burton, which was not received for publication:

ABSTRACT OF ADDRESS BY PRES. WM. H. P. FAUNCE.

IT is written in an ancient document that when one has found a piece of silver, he calleth together his friends and neighbors, saying: "Rejoice with me!" but the finding of a man is more than the finding of silver. When we have the man, the silver will follow. Denison University today calls together its friends from near and far to rejoice in the finding of a new President, who will bring to the position, we believe, public confidence, private benefaction, far-reaching support, and give to this historic institution the period of its greatest efficiency.

In this assembly many kinds of institutions are represented, and there is room for all. There is room for the State University, with its extensive menu of studies whose very names were unknown to our fathers. There is room for the municipal university, working in close co-operation with great industrial establishments around it. There is room for the country college, which ignores technical training and aims simply to adjust the student to his great intellectual and spiritual heritage. No growth in other kinds of institution can diminish the confidence with which we look to Denison University to play its indispensable part in the unfolding of the future. So much of generosity and toil and devotion have gone into it that we must believe those students who are brought up on the altar of self-sacrifice will themselves in turn be willing to sacrifice for college and church and native land.

In three directions the development of an institution like Denison is distinctly different from that of the state universities: First, in its absolute dependence upon private initiative and devotion. The student in a state university can hardly be expected to be grateful for his education, any more than he is grateful for the facilities of the post office or the state roads. These things

come to him by natural right. He may claim them because he was born in America and resides in a certain state. But in a privately endowed university every building means sacrifice, every portrait or bust conveys personality, every tablet or inscription speaks of life-long devotion of individuals, every course of study has been made possible by the self-denial of men who have gone before. Thus the generations are bound together. Thus the past speaks to the present with peculiar inspiration and summons young men and women to dedicate themselves to a great cause.

A second gift of institutions like this is in the line of directness and simplicity. You do not attempt to teach all that can be

known, but to teach things that are essential. You aim not to box the compass, but to chart the main routes over which lives may wisely be steered. You seek to avoid the artificialities and superficialities of the *nouveaux riches,* to dispense with much that gilded youth consider necessary, and to lay aside every weight while you press toward a definite goal.

A third characteristic of such institutions is the profoundly ethical and religious aim. This aim lies much deeper than any denominational propaganda or any attempt at dogmatic instruction. You aim to see life *sub specie aeternitatis,* and to view each small human task as part of the Divine task of creating a world. Still creation is in process, still the morning stars sing

together and the sons of God shout for joy. To have part in such social and moral creation of the world—that is the high destiny of the American college.

ADDRESS BY PROFESSOR WILLIAMS.

IT gives me great pleasure to convey to Dr. Chamberlain the hearty congratulations of this College Faculty. As men and women of this body we do not all think alike with reference to certain matters, but we are one in our attachment to our new President, both as a man and as an official. In our relations with him we have found him very pleasant and very reasonable.

Those of us who were members of this Faculty when Dr. Chamberlain was an undergraduate were very fond of him and for this among other reasons. He did not assume that he was a genius. He was without the affectation of brilliancy. He was without the tricks of mere smartness. He was not ashamed for it to be found out that he had to work very hard for all he gained. Now and then an alleged student saunters into college overstocked with the conceit of ignorance. He is like an empty jar that is hermetically sealed up. The emptiness within is inaccessible. Clark W. Chamberlain was at the furthest remove from that class of young men. He captured a number of prizes, but he did not let them capture him. He had the good sense to make the best of them. He did not rest upon his college laurels. College laurels are not good to rest on. Resting on them is likely to result in contented stagnation. As an undergraduate, as a post graduate, and as a professor he has adorned Carlyle's doctrine of hard work, and that is one of the chief reasons he is today formally inducted into the Presidency of his Alma Mater.

If I am not mistaken, Dr. Chamberlain is a conservative. He is this by nature and by education, too. Nature made the motion and education has seconded it. But his is the conservatism that exists only by going forward. He is one who believes he can keep hold of what he has only by getting hold of more.

We members of the Faculty are conservatives of the same kind. We are none of us so old that we cannot learn anything

more, and none of us so young as to know everything. We are none of us apostles of hind sight, none of us reactionaries. Goldsmith, in his comedy, "The Good Natured Man," makes Mr. Croaker say, when chided for not listening to reason, "Produce your reasons. I'm fixed, determined. When I'm determined, I always listen to reason because it can then do no harm." There is none of Mr. Croaker's spirit in the Denison Faculty, so far as I know. During the last twenty years we have often reversed ourselves, but it has been in the direction of the rising sun. We have frequently changed our minds, but that is one of the things

minds are for. When Mr. Gladstone entered the House of Commons, Macaulay described him as "the rising hope of the stern and unbending Tories." His last speech in that legislative body made by him sixty years later and as the leader of the Liberals, was a stern but dignified arraignment of the Tories for their obstructive policy with reference to his Home Rule bill. The world owes much to the inconsistencies of honest men. The Faculty of this College is conservative enough not to go too fast, and progressive enough not to go too slow.

A Scotch nobleman had on his coat of arms this Latin motto, *Sub pondere cresco*—under a weight I grow. There is nothing in easy berths to promote solid growth in men. Wilkie Collins says of Mrs. Vesey, one of the characters in his novel, "The Woman

in White," that she "sat through life." The incorrigible sitter is pretty likely to sit lower and lower in the scale of life. The Tito Melemas who are always looking for an easy place to slip into and to nestle in are bound sooner or later by the ordination of God to pay the penalty of their selfishness. Only those grow in the direction of full-orbed efficiency who are willing and able to shoulder a load of important responsibility. A balloon rises because it is so light, but a man rises in the esteem of all right-thinking people because of his weight, intellectual and moral, weight developed by his manly performance of duties.

In becoming President of this College, Dr. Chamberlain has undertaken a large task. On behalf of the Faculty I congratulate him because he knows very well the magnitude of the work before him and because he has the courage to undertake it and because of the rich opportunities the position gives him for growth in the most important directions in which a man can grow.

Circumstances do not always make men. If they did, there ought to be more men made. There are many circumstances. A number of years ago some of us in this village received packages of seeds from Washington through a congressman of industrious benevolence. We put some of those seeds into the warm, moist, and welcoming earth, but they did not come up. They were in the best of circumstances. They did not arrive because, as it would seem, they were lacking on the inside. Now and then a small man is placed in a large position. He is very well surrounded, but he himself does not become important. It is not in him to do so.

We are honored in having with us on this platform today a number of men who as college presidents have achieved nobly and notably—Dr. King of Oberlin, Dr. Thwing of Western Reserve, Dr. Thompson of Ohio State, and others. They themselves have become distinguished by making their colleges more distinguished. We of Denison confidently expect that Dr. Chamberlain also will arrive as a college president. We believe it is in him to do so, and we members of the Denison Faculty are ready to reinforce every effort he makes for the enlargement and enrichment of this College.

Mr. George William Curtis once made this fine remark: "A man's country is not a certain area of land with rivers, lakes and

mountains, but a man's country is a principle and patriotism is loyalty to that principle." Principles and ideas belong to the category of things invisible and intangible, but they are none the less real on that account. If you should take out of life all such realities, it would be very much as if you should take all the sap out of the orchards that whiten with blossoms under the coaxing ministry of this May sunlight.

All that this College has been it is now. All the heroism and all the sacrifice of its founders, its early teachers and students are an important part of its present life. If asked, "Where is Denison University " we should, of course, reply "In Granville, Ohio," but not all of Denison University is here. Wherever in this country and in other countries men and women are busy producing values, economic, mental, social, moral, as the result of the awakening they received here and as the result of the ideals and impulses planted in their lives while in this College—there is the inner, the real Denison. President Chamberlain, may God speed you in your worthy work of promoting the interests of Denison, the outer and the inner, as well.

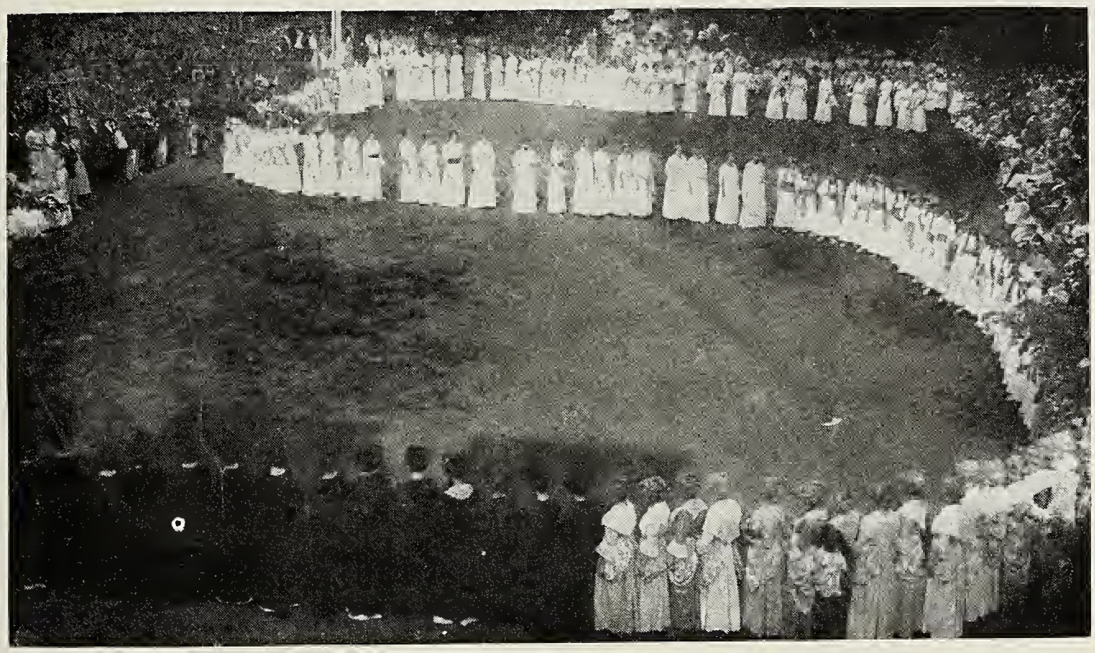
ADDRESS BY MR. CURTIN.

Any member of the undergraduate body of Granville College would be proud to take the role which I as representative am called upon to assume. So anything that I may say on this occasion gives unanimous voice to the feelings of the men of Denison. And in their behalf I extend to you, Dr. Chamberlain, most hearty congratulations upon your assuming the presidency of this college, assuring you of our intense loyalty and support.

In this College's existence of eighty-three years there have been times when the future seemed uncertain, and there have been periods of growth and prosperity, but never in all its history has it been so flourishing or had so bright an outlook as it has today. These beautiful hills and valleys, the atmosphere of peace and quiet which pervades the village, seem to contradict the struggle which was necessary before the Denison of today was accomplished. The opportunities which we now enjoy for the shaping of our manhood were purchased at the cost of struggle and self-sacrifice by those who loved Denison and believed in her future. This spirit of self-sacrifice and love for the insti-

tution did not die out with the founders, but has been handed down to each generation of Denison students as a priceless heritage. This indefinable something, call it what you may, spirit, principle, love, is acquired by every Denison man during his undergraduate days. This is the strong force which binds us forever to the old College and all that the College stands for. This, we believe, is one of the reasons why the Board of Trustees so judiciously selected a "Denison man" as our President.

Doctor Chamberlain, we are proud of the fact that you were a student and a graduate of Denison. We boast of your record as a member of our Faculty, for at that time some of your great-



est work in science was done. We are proud of your distinctions elsewhere, of your great name in science, and of the glory that name brings to Denison.

We, the undergraduates, appreciate that your sympathies are with us and that your efforts are in our behalf. We believe that you will inculcate in our minds the ideals and traditions which are yours as a son of Denison, those which we learn to love during our student days. We have the highest confidence in your intention, and in your ability to do greater things for the College than were possible in the past.

We do not welcome you as a newcomer to us, but we do gladly and proudly welcome you as a former member of our

ranks who has returned to lead and direct our efforts. In congratulating you we are congratulating Denison, we are congratulating ourselves. We pledge to you the loyalty and support which we have ever accorded to past administrations. We gladly welcome you as our President believing in you and in our College.

ADDRESS BY MISS McCUTCHEON.

To step from the undergraduate file and rank of Shepardson women to address this gathering would be no slight ordeal, save for the peculiar pleasure which Shepardson students feel in expressing to you, Dr. Chamberlain, their hearty congratulations upon your assuming the Presidency of Denison University.

Since its founding, seventy-nine years ago, Shepardson College has been under the control of broad-minded, public-spirited educators. Its students feel today very much like congratulating themselves that they have secured as their present leader a man who will not only help perpetuate the ideals of the past, but who will add to these ideals the interest and vigor of a life so largely devoted to the education of college men and women. You come to us, Dr. Chamberlain, after five years of effective service at Vassar College, and in the short time you have been with us as President, you have thoroughly demonstrated that you are in complete sympathy with the higher education of women, and that it will be one of your duties and pleasures here at Granville to lend to that movement your earnest support.

A few months ago you had occasion to address an assembly of Shepardson women. I cannot forget how you told us then that your interest in the higher education of women was one of the things which drew you back to Denison as President.

In a college such as Denison, which is first of all a college of liberal arts, and which has at the same time won recognition for its strong scientific departments, it is peculiarly gratifying that we should have as our head a man whose scientific training and brilliant scientific achievements have been based upon a sound classical course. We feel that as a result, you are in such thorough accord with the ideals of Denison that all of our student problems will receive at your hands a broad-minded and sympathetic consideration.

And so, Dr. Chamberlain, it becomes my privilege to extend to you, on behalf of the undergraduates of Shepardson, hearty congratulations upon your assuming the presidency of a college whose students so gladly welcome you as their head, and who so confidently trust the future of their institution to your leadership.

PRESIDENT CHAMBERLAIN'S INAUGURAL ADDRESS.

Following the speeches of congratulation, President Chamberlain delivered his inaugural address.

On this hill top, dedicated to the cause of education eighty-three years ago, we meet at the call of Denison. This distinguished group of college and university delegates, this great congregation of the friends of education are not here to do honor to an individual, for men may come and men may go, but institutions live. We are met together to reaffirm to our own generation the expressed faith of our fathers, a firm and abiding belief in the Christian college as an essential factor in the prosperity and preservation of the state and nation. It is appropriate that in this expression of confidence in the college and hope for its future, trustees, sister institutions, faculty, alumni and students should have a share, for without the contribution of all these a college could scarcely exist.

To the Trustees: You are a body of men associated for a noble purpose. You have asked me to take a place in your councils; a place once held by John Pratt, Jonathan Going, Silas Bailey, Jeremiah Hall, Samson Talbot, Benjamin Andrews, Alfred Owen, Galusha Anderson, Daniel Purinton and Emory Hunt. These men carried with you and your predecessory an oppressive weight of anxiety, such as is necessarily borne by those charged with the administration of the affairs of a college. It was my good fortune to labor under and with three of these men. When I recall their inspiring personality, wisdom and foresight, their moral worth, their intellectual attainments, their untiring energy, their devotion to the interests committed to their care, I could almost wish you had permitted me to remain in my accustomed field of service. Had my work as a teacher of college youth fallen short of the highest standard it would have been supplemented by the superior work of colleagues and no educational tragedy would have resulted. Had my labors on the frontier of

science, to aid in the clearing of new paths through the wilderness of the unknown, fallen short of a fair measure of success, the failure would have brought no distress to others. Had I been permitted to accomplish anything worthy of record it would have been a record of a beginning and not a continuation. Had I failed, it would have been my own failure and would have brought to ruin no work of abler men. It is a new experience to feel a burden of responsibility extending back to the past as well as forward to the future. You and my predecessors, as co-trustees with you, have directed the affairs of these colleges with such integrity, devotion and love that any mishap which might occur under later leadership would bring grief to thousands of loyal hearts and constitute a public calamity. This conviction intensified the earnestness with which I enter upon my joint labors with you.

Not all Boards admit their administrative officer to their councils. Your Board has followed this order since its establishment. Furthermore, it has given him earnest and loyal support. The president of a college may plan ever so wisely; he may spend himself in its service with an energy and zeal that knows no rest, but unless the Trustees of the college uphold his hands his labor must surely fail. Large encouragement may be drawn from the days that have passed. You have loyally supported the men into whose labors I have entered.

You have had the doubly hard task of directing the affairs of this institution and at the same time of providing the larger share of its resources. Denison possesses no greater asset than the record of the past. Its Board has been served by men who literally gave their lives that the college might live. It is a noble heritage. "Should we live a thousand years, we never could forget it."

To the Representatives of the Universities and Colleges: Your presence here makes public declaration of the fact that no college is sufficient unto itself. Each is indebted to some other for its origin. Harvard had its beginning on the other side of the Atlantic. Dartmouth was born on English soil. Yale reproduced itself in Western Reserve and Brown in Denison, which in turn sowed the seed which later sprang to life in Chicago, on the Pacific Coast and in China. We are engaged in a common task. We belong to one family, and as one prospers so do all.

The State Universities, in the final analysis, owe their origin to the endowed colleges which preceded them and educated a public which today gladly supports higher education by the state. We are not rivals; we never were. We are co-laborers in a field so extensive our combined efforts will till it none too well. As Themistocles said to Aristides, "At all times, and especially now, let this be our only rivalry—Which of us can do the most good for our country."

To the Alumni: The College holds you to be its proper representatives. Your concern in the welfare of the institution in which you grew to intellectual maturity is probably keener than when you daily gathered within its beloved walls and received its instruction. The College looks upon you as the accomplished work of its hands, and a visible example of its service to the public. Through you, in the various activities upon which you have entered, the beneficent influence of the college spreads itself abroad. The college is a throbbing heart, you are the life blood pulsing freely and far carrying vigor and strength in its path.

To the Faculty: I thank you for the hearty welcome extended me by one of your number. Allow me, first of all, a few words to the five men at whose feet I sat in college. Your service has been long and faithful. The friendship which began between us twenty-four years ago as professor and student has been an unbroken one. I like to think that in a certain sense I am here today because of you, and that I am undertaking my new duties with your benediction resting upon me. My lines have fallen in pleasant places; my lot has not been cast among strangers, I appreciate thoroughly your welcome upon rejoining a faculty with which I have already spent eight happy years. I am aware of the importance and difficulty of the educational problems awaiting solution. I shall endeavor to approach them with an open mind. It is not my purpose at this time to outline a policy. Were I to do so I should stamp myself as unfit to serve in the place to which you have welcomed me. The necessity of organization would seem to require that a college should have an executive head, and yet if it is to maintain efficiency as an educational institution, if it is to win distinction it must rely upon the scholarship, ability and energy of the members of its Faculty. Laboring together we shall hope to produce educational

results worthy of approval. I sincerely hope every man in the Faculty firmly believes his own department the most important one in the college. Of course, you will not expect the President to entertain the same opinion. It will be his duty to maintain a proper balance. A weak spot in our educational armour can not be offset by reinforcement at some other point.

To the Students of Granville College: Do I need to tell you that I love young men. It requires no effort to establish a bond of sympathy between those who have walked the same paths, dwelt in the same halls and received instruction from the same teachers. You are not the only ones who receive. Your teachers are constantly warmed by the ardor and hopefulness of the young. May the government of the college always be based upon complete confidence, spontaneously expressed between you and those who seek to serve you.

To the Students of Shepardson College: Upon the campus at the foot of this hill a high type of education for women was maintained at a time when an eastern college president declared it to be "faddish to say that a woman could comprehend college mathematics, or master the Greek verb," and a professor of Philosophy said that "the effort to teach women his branch of study was beyond his comprehension." The movement for the higher education of women began by Emma Willard at Troy, Catharini Beicher at Hartford and Mary Lyon at Ipswich and Holyoke had its counterpart in Granville. Shepardson College stands as one of the movements of that struggle against heavy odds.

The origin of the two colleges, in whose honor we meet today is a close reproduction of the beginnings of the long train of colleges stretching south and west from New England fostered by a religious impulse for higher education. The passion to serve humanity led the people everywhere to contribute of their wealth and of their poverty to the establishing and endowing of colleges. With very few exceptions the colleges were the offspring of the churches. The church as an organization represented the highest ideals of the community. The intellectual activities of the people were almost wholly centered in them. Their highest ideals found expression through their religious organizations. It was natural that the churches should interest themselves in the establishment of colleges. In most instances

the colleges were organized not alone for the propagation of the faith through the provision for an educated ministry, but to secure a higher type of civilization. In the western states as in New England the colleges, generally established in the name of the churches, represent one of the churches' contributions to the welfare of humanity. They have generally interpreted their responsibility to the public in no narrow spirit. The Christian colleges have made great contributions to the creation of literature, the development of art and the promotion of civilization. It is doubtful whether higher education in the United States could have reached its present high standard without this contribution from the colleges founded under Christian leadership. The number of educational institutions founded in the nineteenth century which in their origin had no relation to religion in either a personal or organized capacity is very small.

Has the Christian college completed its task? It has sown its seed in fertile soil. It has sown broadcast. The harvest has been abundant, and gathered by the public. Through the early labors of the endowed colleges the need for higher education has been so impressed upon the mind of the people that there has arisen a public demand that full and complete provision be made. Thus have our State Universities sprung into existence. Shall the colleges which have borne the heat and burden of the day retire from the field? Is there room for both; is there need for both types of instruction? The colleges resting on private foundations could not care for the great army of students now thronging the doors opened to them by the state. Their resources are already taxed to the limit of endurance. The task immediately ahead is so enormous that assistance from every source is heartily welcomed. The Christian college needs the aid of the tax supported institution in solving the educational problems of the commonwealth. Does the University supported by the State need the assistance of the Christian college? In the progressive social order the religious motive has generally expressed itself earlier and in a more vigorous manner than the human. In this way it was possible for men to move more rapidly through their church organizations in the establishment of higher education than was possible for the state in its collective capacity. The sequence has been a natural one,—individual religious purpose, organized churches, Christian colleges, an edu-

cated public and universities provided by the commonwealth. So long as human nature remains as it is, the incentives which led to the establishment of Harvard, William and Mary, Yale and all the Christian colleges established after them need to be preserved. The problems of education have not all been served. The present day, like all other days, is a period of hearts searching in the universities and colleges. We are in the midst of radical readjustments. The public perspective is sometimes faulty. It is a serious thing to permit popular clamor to shape policies of institutions of higher learning. The State University within our own commonwealth is already looking to the privately endowed colleges to preserve certain educational ideals and maintain them before the public mind. The parent institutions, the Christian colleges, under the influence of the ideals of their founders, ideals which have been preserved to this day, have maintained a type of higher education by which the character and social usefulness of the student has been highly developed. The purpose of their colleges is to prepare men and women for competent social living. The character of the State Universities is not under criticism. They and the colleges maintain a feeling of mutual confidence and respect. Nevertheless, the latter possess many elements of stability, and means for directly and effectively gaining educational results which are denied the former. It augurs well for the future that the two types of institution have labored side by side in complete harmony. The day is rapidly passing when it is easy to win applause by referring to the State Universities as godless institutions, and we smile at the doubt expressed by the dean of the western college of engineering who advises against the admission of a Denison graduate on the ground that theological students should not attempt graduate work in engineering, and this at a time when Denison men were being welcomed to the staff of the Carnegie Institution of Washington and the Faculty of the Massachusetts Institute oi Technology.

It should be said to the credit of the endowed colleges that their curricula have kept abreast of the times. As to what constitutes the fundamental principles of a truly liberal education perhaps no two of us would agree. When in 1841 Harvard introduced scientific studies into the curriculum Professor Kingsley of Yale wrote to his colleague, the first Professor Silliman,

"Let them try experiments at Harvard, and we will try to profit by them. They are better able to experiment than we are." Is not the curriculum at best an experiment? President Harper once said, "What is the college for, if it is not to experiment?"

We think the curriculum of the early college—the curriculum of Greek, Latin, Mathematics, and Philosophy—as aimed to accomplish the ends of culture, as though it had no immediate and practical purpose. We should not forget that at the time of its establishment the old curriculum was intensely practical. It prepared directly for the professions of the day. It was a training in Latin, the common language of scholarship, in Greek, the language of the best literature and together with mathematics and philosophy constituted a practical preparation for the professors of law, medicine and theology. The number of its program of studies and prepare its students to serve their time and generation efficiently and well.

As you have already been told, the greater part of my life has been spent in the study and in the teaching of Physics. I love that study because it possesses so much of beauty and casts such a benign influence upon the mind of him who pursues it. It possesses the power to awaken a profound feeling of reverence toward God. The revelations of the laboratory are so wonderful one cannot escape the feeling that the Creator has spread His wonderful works before us that He might draw men to Himself.

This College escaped to a very remarkable degree the curious and discouraging opposition to science which in many institutions grew out of the misconceptions of the religious world. These misunderstandings first arose through a false natural science which had been written before the methods of Bacon and the experimental work of Galileo laid the foundations for modern physical science. The early scientists based their work, not upon experiment and the principle of induction, but upon hypothesis strangely interwoven with conclusions drawn from sacred writings. These supposedly scientific conclusions were the product of fertile imagination unguided by intelligent questions put to nature. "De Principii's Rerum Naturalium" was the only science of its day and was taught everywhere in the medieval schools. It assumed to be founded on revelation and became hopelessly mixed with religious faith.

When experimental science had its birth it met with formidable opposition from the religious world. The old philosophy was disproved, but the breach caused by the discussion was a long time in healing. In all fairness it ought to be said that the difficulty had its origin in a faulty Physics and unscientific methods.

The shelves of libraries are still burdened by many volumes written on the conflict between science and religion. While discussion was rife in many institutions this College was quietly proceeding to the establishment of its laboratories and the publication of its scientific bulletins. It gained an early start and would seem to have contributed its fair share to scientific progress.

The work of the laboratories of this institution represents only a portion of its activities. It has faithfully endeavored to produce a well balanced type of education. It maintains its original purpose to fit men for comprehension service. Founded as a Christian college it maintains its original purpose, to teach those under its care "to know God aright, and out of that knowledge to love Him, to be like Him as we may be nearest, by possessing our souls of true virtue, which being united to the heavenly grace of faith, makes up the highest perfection."

THE DENISON GLEE CLUB

After the Inaugural Address of President Chamberlain, the Denison Glee Club rendered:

"Invictus" .... *Bruno Huhn*

THE CONFERRING OF DEGREES

Then followed the conferring of honorary degrees. The recipients were presented by Dean Richard Steere Colwell, A.M., D.D., Professor of Greek, by Professor Alfred Dodge Cole, A.B., of the Board of Trustees, Professor of Physics and Head of the Department, Ohio State University, and by Professor Frank Carney, Ph.D., Professor of Geology. The appropriate hood lined with Denison red was placed over the candidate's shoulders as the degree was conferred upon him. The following ritual was used:

Dean Colwell. Mr. President, I take pleasure in presenting to you for the honorary degree of Doctor of Laws, WILLIAM HENRY PERRY FAUNCE, a graduate of Brown University in the class of 1880, a preacher of the Gospel of national repute, an educator of the first rank, since 1899 President of Brown University.

President Chamberlain. William Herbert Perry Faunce, distinguished son of Brown, trustee and for the last fifteen years president of your alma mater, the university which furnished Denison with its first, second, third, and sixth presidents, profound student, effective preacher and Christian teacher, I welcome you to the degree of Doctor of Laws, with all the honors and privileges pertaining to that degree.

Professor Cole. Mr. President, under the authority of the Board of Trustees, I have the honor of presenting the distinguished physicist, who with his marvelously sensitive dadiometer proved the existence of the long-sought pressure of light and the heat radiation of the stars, who later directed other investigators along the paths of scientific discovery, and finally became the efficient administrator of one of the most celebrated colleges of the East, ERNEST FOX NICHOLS, President of Dartmouth College, for the degree of Doctor of Laws.

President Chamberlain. Ernest Fox Nichols, President of Dartmouth College, cogent and able thinker, productive investigator of high distinction, skilful administrator, inspiring and beloved teacher, upon the recommendation of the faculty and by the authority of the trustees I welcome you to the degree of Doctor of Laws, with all the honors and privileges pertaining to that degree.

Professor Carney. Mr. President, at the request of the Board of Trustees, and on their behalf, I have the honor to present to you for the honorary degree of Doctor of Laws, RICHARD COCKBURN MACLAURIN, an eminent scholar, inspiring teacher, and able administrator in engineering education.

President Chamberlain. Richard Cockburn MacLaurin, President of Massachusetts Institute of Technology, productive scholar in mathematics, physics and the law, trained in the universities of New Zealand and Cambridge, meeting the vast educational problem of your adopted country with originality and force, I welcome you to the highest honor in the gift of this in-

stitution, the degree of Doctor of Laws, with all the privileges pertaining to that degree.

Following the conferring of degrees, the assemblage, led by the College Choir, united in singing "Granville," written by Francis Wayland Shepardson, A. B., of the Class of 1883:

Down among old Licking's hills,
There is a place my memory fills,
And my heart with rapture always thrills,
  When I think of Denison.

Granville, I love thee,
Valley and hill,
Fondly my memory clings to thee still.
Granville, I love thee,
Present and past,
While time endures this love
  For thee shall last.

Wherever I may make my home,
However far from her I roam,
Thoughts of dear old Granville oft will come
  To a son of Denison.

Granville, I love thee,
Thy skies so bright
Bring back as years pass by
  Naught but delight.
Granville, I love thee,
  Till time is done,
Hail! Alma Mater, hail!
  Old Denison.

BENEDICTION

The Reverend Henry Fenton Stilwell, Pastor of the First Baptist Church of Cleveland, pronounced the benediction:

Almighty God, our Heavenly Father, we pray that Thou wilt follow with Thy rich blessing our services of this hour. May the

grace of the Lord Jesus and Christ, the love of God, and the communion of the Holy Ghost, abide with us all. Amen.

This closed the exercises on the Campus.

DINNER TO DISTINGUISHED GUESTS, ALUMNI AND FACULTY, GIVEN IN SWASEY GYMNASIUM BY THE TRUSTEES

Shortly after one o'clock, guests, alumni and faculty gathered at a dinner given in Swasey Gymnasium by the Trustees of the University. Rev. Herbert Fenton Stilwell, A.M., D.D, of the Board of Trustees, in the unavoidable absence of Charles T. Lewis, Esq., A.B., who was to have been the presiding officer, acted in that capacity. Mr. Stilwell very fittingly opened the exercises, and introduced the speakers. To the deep regret of all, President Thwing, and President Thompson were obliged to leave before delivering their addresses. The address of President Nichols, and of President King are given below:

Mr. Stillwell. I rise to express, in the first place, our very keen regret that Mr. Charles T. Lewis was, at the last moment, prevented from meeting with us today and presiding over this feast of good things. No member of the committee has been more enthusiastic in the expression of his interest in this event.

In the absence, therefore, of Mr. Lewis it has fallen to me to express in a few words the very delightful appreciation on the part of the members of the Board of Trustees of the University that such a goodly number of friends from far and near have so graciously honored us with their presence on this great day for Denison. We naturally are deeply interested in the affairs of the college, and we believe we are justly proud of our University not only because of what it is but because of where it is. As numbers and equipment go, Denison is not one of the largest colleges in America, but there are many of us here today who believe that there are valuable advantages in the smaller institution. All of us, I am confident, believe that there are peculiar advantages in such an environment as Denison presents for the acquiring of an education and the culture of character.

We are come to a time when the requirements are vastly different from those which were imperative when some of us were

in college; however insistent some of those requirements may remain there are new problems which are very alive today and keen with interest. Society in all its phases seems bewildered and perplexed. Some things must be settled before there can be that character of assurance which makes for comfort and confident advancement. Never were many problems so real; never were so many men so sincerely and earnestly reaching after their solution. Some of the most disturbing circumstances are in the industrial groups and among the toilers. We have come to realize that these disturbances are not to be quieted upon a financial basis solely. They are too widely inter-related socially, and indeed racially. They are to be settled only after intelligent investigation. Balanced poise and positive character are essential to the investigator.

Two or three things are necessary to the creating of a poise in our living. One is the motive which actuates the pursuit of an education, this is the constant thread which is woven into the fabric of the character. Another is the environment in which the process of character building proceeds. For some years I have been rather intimately questioning which were the more promising conditions: those which obtain in the quiet secluded spot where beautiful physical surroundings silently but constantly conduce to beautiful and lofty inspirations, or those which surround the municipal school where the more vigorous type of life manifests itself with the many voices of the great city. Which will produce the better all-round man Which will the better aid in the creation of most beautiful womanly character? It is conceded that there are advantages either way, greater than we are apt readily to appreciate, yet I confess to a decided inclination toward the smaller college where the fellowships are more intimate, and especially to the college located as is this one where Nature has been so lavish in her expenditures for beauty, where the physical surroundings are full of helpful inspirations.

Another element which we here regard as essential to the best type of life is that which we call Christian. We seem to have grown away from some of the limitations which used to surround that term. In my college days the Christian school had mostly to do with denominational interests. These have their values and should never be treated with indifference, but the Christian institution is larger than that conception. The

Christian college may not bear the stamp of any religious body; it may be the college in the heart of the great city; it may mean a school in a secluded spot such as this; it always will mean an institution looking toward life's best relationships with Jesus Christ.

We are inspired today with a larger faith than ever before in the possibilities of Denison. We felicitate ourselves upon the auspicious opening of this new administration. I am sure we take profound satisfaction in the reaffirmation of our faith in the importance of the Christian College in the upbuilding of society and in the development of the highest type of the individual man and woman.

ABSTRACT OF ADDRESS BY PRESIDENT NICHOLS.

What is a college for? What kind of public service should our colleges perform, and how should they go about it?

These are questions in which the public just now is a good deal interested. Many recent public utterances on the subject have been sane, helpful, constructive; others have been trifling, petulant, uninformed. Some criticism, of both sorts, have come from the colleges themselves.

Fifty years ago few people thought of asking questions about colleges, and fewer yet took the trouble to reply to them, when asked.

Why is there now so much criticism where formerly there was so little?

In this case public interest and public discussion are signs of health rather than of disease. In all public discussions, however, we must remember that it is mainly the dissatisfied people who do most of the talking.
professors has increased and the college is called upon to enrich

There was little or no public discussion of our colleges fifty or sixty years ago because, in the previous half century, few changes had been made, either in the subjects taught or the methods or equipment used in teaching them. A college education was then considered a personal privilege and advantage to him who got it. Now college education is considered as an asset to society and to the state.

Today, whether or not a man has had college training, is seen to be a matter of importance to more people than himself and his friends; also the kind of education a college offers interests a wider circle than its students and graduates, for it has become a recognized concern of everybody.

Prolonged public discussion, here as elsewhere, is a measure at once of the public interest and the public estimate of the importance of the thing discussed. More people are discussing our colleges because more people are interested in them. So contagious has this interest become that some who have never seen a college feel no hesitation in entering the discussion.

Whenever a majority of the people first realizes that some large thing belongs to them, that it exists solely for their welfare and advancement, it is natural that some wisdom, and a deal of nonsense, should be talked about it.

In the midst of the resulting clamor and confusion, however, it is necessary that a considerable body of informed men and women should keep their heads, and not be swept from their intellectual moorings by the sheer volume of a disordered discussion.

For example, the public loudly demands that our colleges train men for citizenship. You will look long to find a better group of citizens than the body of alumni of any of our colleges. Whether any new and untried method of training citizens will serve the people better than our present ones is open to question.

Again, the public demands that colleges train men for the public service. Colleges have always trained men for the public service. The larger affairs of state and nation today are predominantly in the hands, and under the guidance, of college bred men who are carrying the heaviest burdens of public administration and public responsibility, and carrying them better, on the whole, than those burdens have been carried before.

The public demands that the colleges prepare men for business. Yet any careful observer, today, will tell you that the conduct of our largest business enterprises is steadily and inevitably drifting into the hands of college men.

In addition to these and other public demands which the college, unknown to many, is already meeting, and meeting them well, there are many more demands which the college, as opposed to the university, cannot consistently undertake to meet.

The important matter in all this discussion is that there is one great service which is too rarely emphasized, but is yet a service which the college, whatever, else it does, must continue to render. If it fails here it will fail everywhere, for without this none of its work can stand.

Thus I come back to the opening question, What is a college for?

I but put the one great and historic purpose of the college in modern terms when I say that, first, last, and always, the chief business of the college is the conservation of men and women; the conservation of the nation's highest intellectual, moral and spiritual resources; those finest and strongest qualities of mind and heart, of will and spirit.

We have grown accustomed to think of the conservation of the nation's natural resources. State and national governments have reiterated the importance of economies in the use of our inheritance in nature's bounties, the importance of saving so that the nation, and those who come after us, may be assured of the means of comfort and the sources of material power. Yet few have risen to warn us that, unless we can conserve and increase the nation's highest intellectual, moral and spiritual resources, our material economies will go for naught, for a luxury-loving and morally inferior race which may follow us will spend these cherished material bounties in riotous living, spend nature's substance in ways which will weaken, and not strengthen, the people.

Stop for a minute and think. What is the real root of the unstable and distracted condition of the Mexican people today? Natural resources they have in abundant profusion. Nature has given them more than they have intelligence, initiative, or ambition, to develop. The root of the trouble is that Mexico is a nation without sufficient intellectual, moral and spiritual resources; and without these no nation can become either strong or enduring. Any people which has once had these resources, and is in danger of losing them, may read Roman history with profit.

There are four institutions pre-eminently consecrated to the conservation of men: the Home, the Church, the School, the College.

If our homes go wrong; if through blindness, selfishness, or ignorance, we are making mistakes with our children; if we

are losing the spirit of reverence; if we are abandoning our churches; if along with a vigorous mental discipline in school and college we yet fail to maintain a robust morality, a virile idealism; then we cannot succeed in the indispensable work of the conservation of men.

Only so long as we conserve the nation's highest intellectual, moral and spiritual resources, only so long shall be continued a righteous, a strong, and a free people.

There is one question, before all of these, which we should ask of every college, and we may ask the same question of every home, every church, every school. Is it, or is it not, conserving the nation's highest and strongest resources in mind and heart, in will and spirit?

ABSTRACT OF ADDRESS BY PRESIDENT KING.

Dr. Chamberlain, friends of Denison University, I am sure my first word ought to be a word of very earnest congratulation from the college I have the honor to represent. I congratulate Denison University on the splendid work that it has done in years past and the very bright prospects that it has before it. I bring this word with great pleasure.

Once I stood with a few of my colleagues in front of the St. Louis station when a man who had had too much to drink asked the name of the building from which we had come. He said, "I bin in it and just wanted to check it off." There has sometimes been a fear that college students were taking their courses in the same manner.

What may the College be reasonably asked to do for the students committed to its charge?

First of all, it would seem that the College ought to enable its students to enter into our great historical inheritance, Greek, Roman, Jewish and European. Our civilization is in the direct line of intellectual, moral and religious descent from ancient Greece and Rome and Judea and from modern Europe, especially Great Britain. We are fond of quoting Bacon to the effect that we are the ancients, because the last generation has always the advantage of a larger experience than any generation that has preceded it. But we should remember that we can make this claim to be the ancients, only if we have entered with some real understanding and personal appropriation into what the past has ac-

complished. The very idea of a scientific evolution compels us to recognize that we cannot truly know our own time without knowing it genetically. The College may be held, therefore, as bound to introduce its students to the significance of the great lines of inheritance already mentioned. Doubtless the modern college cannot give the same proportionate amount of time to Greek and Latin, for example, as the older college course, but it ought not to make the mistake of cutting its students off from the rich lessons to be learned from the study of Greek and Roman and Jewish and English literature and history, as related to modern life and problems. How can a man be an educated man who has not worked his way through some of the problems presented in Literature and Art. One thing that may startle the tables here is that there are not a few doctors of philosophy who can not give an elementary presentation of Christianity. Our heritage is among them.

But the whole task of education may be said to be that of fitting a man to enter intelligently and unselfishly into the life and work of his own generation, as well as to get such a genetic understanding of the civilization of his own time as has been already mentioned. We cannot really understand our present culture unless we link it up with the past. For our own time this peculiarly means that the college should help its students to some genuine personal sharing in the scientific spirit and method, in the historical spirit, in the philosophic mind, in esthetic appreciation, in the social consciousness (including insight into economic conditions), and in religious discernment and commitment; and every one of these great outstanding characteristics of our time is very closely related to the Christian spirit that would inform the whole life of the Christian college.

I really do not believe that a man is intelligently fitted to come into the life of the present who has merely heard of the problems of today but who has been in them. We boast a scientific age but this should mean that the leaders of this age should occasionally have shared it and not only hear about it. It is to the honor of Denison University that its students have been trained in science. It should mean that the students have formed the habit of reporting exactly,—that is involved in the scientific spirit.

No closer historical parallel, in the first place, can probably be found to the scientific spirit and method than in Jesus' persistent demand for inner integrity; for he, too, demands of men that they should see straight, report exactly, and give an absolutely honest reaction upon the situation in which they find themselves. The historic spirit demands the ability to put oneself at the point of view of the other man, of the other race, of the other time and clime, and to see things through his eyes, from his point of view. But this, like the scientific spirit, requires a moral quality—the quality demanded also in any true application of the golden rule. The philosophic mind demands that one should see life steadily and see it whole; should grasp something of its real significance. And no time has needed more this interpretative mind than our own complex, transitional and revolutionary age. Here, too, philosophy has an interpretative task very much like that of religion itself. How close esthetic appreciation lies to the sense of moral and religious values, may be seen in the way in which mankind has always instinctively associated truth and goodness and beauty, and in the further fact that the great method in all these spheres of value is the same method of staying persistently in the presence of the best, with honest response.

It is still more clear that the social consciousness that has so characterized our age and constituted its highest glory, is in the closest sense akin to the Christian spirit. I do not believe we are sending men out into a modern age prepared for the modern life who have not partaken of this spirit. Now and then a university club has shown that they have had no relation with this peculiar mark of our time. Wherever this happens, it seems to me that we fail to send them out prepared intelligently in their own hearts. For the insistence of the Christian spirit on the essential likeness of men, on their inevitable and indispensable mutual influence, and on the sense of priceless value and inviolable sacredness of the individual person—all this is only a modern translation of Jesus' central faith that every man is a child of God.

And most of all, of course, the Christian College believes in the fundamental nature of religion; that men must finally ask ultimate questions; that there can be no permanent meaning

and value to life without the conviction of an infinite purpose of good back of the universe; without faith in a heart of love in all life. For, as Euken says, so characteristically for our time, "Not suffering but spiritual destitution is man's worst enemy."

In all these most vital respects, therefore, we may believe that the Christian College is peculiarly fitted to give to this generation the education needed, and to prove the permanency and value of its task.

Mr. Stilwell. The time has arrived when we must terminate these very delightful exercises. They have been most gratifying in every detail, and on behalf of the University I desire to express to all who have in any way contributed to this splendid realization of enjoyment, our very sincere appreciation. I feel assured that by this time the President must feel that he has been not only very thoroughly inducted into his high office, but that also he has been given a large place in our affections and that we have enthroned him in the very center of our confident hopes for the future of Denison University.

It would not be surprising if the president and his good wife were a bit impatient to express some of the functions of their privileged position. They have desired to continue the felicities of this day in the pleasure of extending to the friends and guests of the University the courtesies of their hospitality. We are most cordially invited, therefore, upon leaving this hall to repair to the home of President and Mrs. Chamberlain. We will now adjourn.

DENISON UNIVERSITY PRESIDENTS.

PROFESSOR W. H. JOHNSON

It could hardly have occurred to the founders of Denison, in 1831, to look elsewhere than to the East for its first executive. No western institution had as yet acquired the age and facilities necessary to the production of a graduate fitted for such a position. As the founders were Baptists, actuated by a desire to have better educated men for the ministry and to have their own sons educated under religious influences, they turned naturally to Brown University and selected the Rev. John Pratt, who had received the A.B. degree from Brown in 1827. Mr. Pratt was but thirty-one years of age when he took the position. He was a vigorous worker under extremely trying conditions, and but for his persistence the attempt might easily have failed before it had won a sufficient hold upon the Baptist people of Ohio to secure the aid of a permanent endowment. But the work of the presidency did not apparently suit him and in 1837 he gave it up, retaining a position in the faculty as Professor of Greek and Latin. In this capacity he served for twenty-two years, winning with his pupils the reputation of an exceptionally well prepared, thorough and energetic teacher.

It had been necessary to begin at the very bottom, with a preparatory school, and the first class of college students did not reach the point of graduation until three years after President Pratt had resigned his executive duties. The second choice also fell upon a graduate of Brown, the Rev. Jonathan Going, who had taken his bachelor's degree in 1809, the master's degree from the University of Vermont in 1812, and had been honored with the degree of Doctor of Divinity by Waterville College (now Colby) in 1832. With the first graduating class at the end of its freshman year when Dr. Going took the presidency, and with a Brown man as his predecessor and still present in the professorship of Greek and Latin, it was inevitable that the ideals of the college and the content of its course of study should follow closely the example which Brown had set. President Going held the position only seven years, being removed by death in 1844.

Tradition represents him as a man of genial temperament, with a keen sense of humor, and an energetic worker, exercising a strong influence for good in the college and the community. And the annals of the Baptist denomination show that his influence was weighty in its religious and educational activities throughout the country. Before coming to Denison he had been especially active in organizing the Home Mission work of the denomination, and this had impressed him with the need of better educated men, not only in the ministry but among the laity as well. And his sympathies extended beyond his denomination, since he had served as one of the original board of trustees of Amherst College.

After a vacancy of more than a year, the Brown tradition was continued in the selection of the Rev. Silas Bailey, a graduate in the class of 1834. During his term of service the lack of funds still made it necessary for the President to teach five or six hours each day, and he also served most of the time as acting Pastor of the Baptist church. There are still those in the community who remember him as a pulpit orator of great power, but his influence was finally undermined by the belief that he was favorably inclined to a proposition to remove the college to another part of the state. Such favor as he had shown to this proposition was not really discreditable to him, since it was merely the result of the inability, so far, to secure adequate financial support for the college at Granville. But the movement failed, and the feeling which it had engendered led inevitably to his resignation, in 1853, and to a material loss from the student body.

A convention of Ohio Baptists had been held to consider the question of removal of the college. In that convention the Rev. Jeremiah Hall, then pastor of the Granville Baptist church, made a motion that the friends of Granville be given six months to raise for the college the sum of $50,000, one-half to be subscribed within the county, and that in case of the success of this effort all agitation for removal should cease. The motion was adopted, Dr. Hall was chosen to the presidency which Dr. Bailey had resigned, and the money was duly raised. The location of the college on a farm, a mile or more from the village, had been one of the objections raised in the effort for removal, and it was at this time that the present site was secured and the

college brought within the limits of the town. President Hall was an eastern man, but had never taken a college degree. He was a man of solid qualities, however, and well fitted for the service which the college required during the ten years of his presidency. The Civil War had badly broken down the attendance during the last two years of his term, but the money which he had been instrumental in raising and the change of site from the farm to the hill in the north side of the village were important steps toward insuring the permanence of the institution.

Dr. Hall was succeeded by the Rev. Samson Talbot, a graduate of Denison in the class of 1851. Though he had not been engaged in educational work, President Talbot immediately developed unusual force as a teacher. He had a wide range of intellectual interests and was an independent thinker, making a profound impression on the students who sat under his teaching. On the material side he saw at once that the college could not take its proper place among the growing educational institutions of the country except by means of an enlarged and better paid faculty. He at once set himself at the task of raising an endowment fund, and with a success really remarkable, for the time. With most American colleges fifty years ago, the raising of $100,000 was an achievement equal to five times that amount today. After President Talbot's endowment campaign there was no longer any room for doubt as to the permanence of Denison. But his enthusiasm and his deep sense of duty had led him to labor beyond the limit of his physical endurance, and a swiftly fatal break in health came in 1873. Morally, intellectually and materially he had been a builder of great power.

For an interval of two years the executive duties of the college were performed by Professor Fletcher O. Marsh, as Acting President, and then the Rev. E. Benjamin Andrews, a graduate of Brown in the class of 1870, was called to the position. Although President Andrews remained in Denison only four years, his vigorous personality made a deep impression on the college and the community. He was followed by the Rev. Alfred Owen, D.D., of eastern birth, and educated in Waterville College (now Colby). During Dr. Owen's administration, which closed in 1886, the productive endowment was increased by nearly fifty percent and additions were made to the teaching force. He was succeeded after an interval of six months by the Rev. Galusha

Anderson, LL.D., who remained only until June, 1889. Dr. Anderson was a graduate of Rochester University, a deep thinker and a man of vigorously maintained opinions, wielding a strong influence in the class-room, the pulpit and the community. It was in the first year of his presidency that the Young Ladies' Institute was transferred by Dr. Daniel Shepardson to the Baptists of Ohio, taking the name of Shepardson College and adopting courses of study identical with those of Denison.

Dr. Daniel Boardman Purinton succeeded Dr. Anderson and held the presidency until June, 1901. He was a graduate of the University of West Virginia, and though a licensed preacher, occasionally occupying the pulpit, he was a member of the faculty of his alma mater from the time of his graduation, in 1873, until his call to Denison. While he made his impress as a scholarly and effective teacher, the most striking feature of his administration was the growth in buildings and endowment. The Barney Memorial Science building took the place of the scattered laboratories of earlier years and made possible a great advance in the extent and effectiveness of science teaching. The Doane Academy building was erected, and Recital Hall built for the Conservatory. The Dining Hall, now known as Shepardson Commons, was erected, and in 1900 Shepardson College was made an integral part of Denison University. In June of the same year an additional endowment fund of $250,000 was completed.

In 1901, President Purinton went back, as president, to the University of West Virginia. He was succeeded by Dr. Emory W. Hunt, a graduate of Rochester University. The twelve years of President Hunt's administration were years of continuous growth. The increase in attendance had been so marked that a little more than half of the living graduates at the close of his term of service held diplomas bearing his signature. Of course this is partly due to the fact that diplomas were now given to women, but the increase in men graduated was also large. In material facilities his administration secured the erection of Cleveland Hall, which houses the Gymnasium and the Y. M. C. A., of Stone Hall, a dormitory for young women, of the Doane Gymnasium for young women, and of the Swasey Observatory. The Barney Science Hall, partially destroyed by fire, was rebuilt in fire-proof construction and thoroughly re-equipped.

It has not been feasible in these paragraphs to trace in detail the development of the curriculum. Let it suffice to say that the range of studies offered has been broadened, the faculty enlarged, and the specific equipment for instruction in the various departments improved, in such proportion as increased income has made possible. The presidents whose administrations have been briefly sketched have been actuated by high educational ideals. To their successor, whose induction into the presidential office is described in the preceding pages, they have neither left nor attempted to leave a complete structure. Rather they have planted and brought to bearing a vigorous tree, from whose growing limbs wise care may hope to harvest a continually improving quality of fruit for untold years to come.

THE FAUNA OF THE MORROW GROUP OF ARKANSAS AND OKLAHOMA

KIRTLEY F. MATHER

INTRODUCTION

The Morrow fauna is of unusual interest paleontologically because of the intermingling of forms displaying a strongly Mississippian aspect with those of as equally strong a Pennsylvanian facies, which stamps it as transitional between the faunas of the two periods named. The large number of new species and the presence of several genera not previously known to occur in the Pennsylvanian formations of North America add to its intrinsic interest. Stratigraphically it is of importance because of the light which it throws upon the early Pottsville marine life of this continent. The occurrence of a fossil flora of known relations between two of the fossiliferous horizons in the group makes possible a correlation with the non-marine or brackish-water formations of early Pennsylvanian age in the Appalachian trough; the fauna will therefore serve as a connecting link between the marine Pottsville of the west and southwest and the contemporaneous non-marine deposits of the east and northeast.

The collections made by the writer were obtained during the three school years 1911-1914 while a member of the faculty of the University of Arkansas situated at Fayetteville in the center of the area of outcrop of the Morrow strata. Determinations were made and descriptions prepared during the winter 1914-1915 in Walker Museum, the University of Chicago, where the types of all new species have been deposited.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge my indebtedness to L. C. Snider, A. H. Purdue, and R. D. Messler for the collections of fossils made by them, as recorded in the locality list, page 247, and to H. D. Miser and also Mr. Messler, for suggestions as to

localities where fossils might be obtained. In the preparation of the manuscript my wife has rendered valuable assistance. Especially am I under obligation to Dr. Stuart Weller for the kind assistance he has so freely given during every stage of the work, in the identification of species, in the comparison with type and other fossils in the Walker Museum collections, and in the preparation of descriptions and illustrations, as well as for access to his library and manuscript bibliographies.

Description of the Morrow Formations

The series of limestones, sandstones, and shales which is known as the Morrow Group occupies a considerable area along the northern and northwestern slopes of the Boston Mountains in northwest Arkansas and northeast Oklahoma. In the type region, near the town of Morrow, Washington County, Arkansas, the group is composed of two formations: the Hale formation below and the Bloyd shale above.

The Hale formation ranges in thickness from about 100 feet to nearly 200 feet and consists of a variable series of sandstones and shales with lenses of rather pure limestone. Usually the basal portion is sandy shale, with thin layers of ripple-marked sandstone, which grades upward into a more or less massive calcareous sandstone. The relative amounts of sand and lime are by no means constant nor are the beds persistent in character but change within short horizontal distances.

The Bloyd shale resting comformably upon the Hale formation ranges in thickness from 100 to 200 feet. It consists almost entirely of black, thin-fissile, carbonaceous clay shale of uniform character. Near the base of the Bloyd and separated from the Hale formation by 5 to 10 feet of the black shale is the Brentwood limestone lentil. The latter generally consists of two, or at some places of three or more, beds of gray fossiliferous limestone, each from three to ten feet thick, separated by beds of the black shale in which it occurs. The upper part of the limestone is hidden in most places, but its total thickness, including the intervening beds of shale, may be as great as 40 or 50 feet. In the upper part of the Bloyd shale, generally within 60 or 75 feet of its top, occurs the Kessler limestone lentil. It is a compact, gray to chocolate-colored limestone, in places conglomeratic

and of variable thickness but always thinner than the Brentwood. Midway between these two limestone lenses there is in many places a seam of coal ordinarily about eight inches, but in some instances as much as fourteen inches, thick.

The three limestone horizons, in the Hale, the Brentwood, and the Kessler, are highly fossiliferous and contain the fauna which is the subject of this report. Associated with the coal seam in the Bloyd shale a fairly abundant fossil flora has been found.

Westward and northwestward from the vicinity of Morrow the sandstones and shales of the Morrow group decrease in thickness and the formations become more calcareous, while to the eastward and northeastward the limestones decrease in importance and the group is composed almost exclusively of clastic sediments. In Oklahoma it is not practicable to subdivide the group and the whole series, composed dominantly of limestone, is known as the Morrow formation.

Stratigraphic Relations of the Morrow Group

The Hale formation, or the Morrow to the westward, rests unconformably upon the Pitkin limestone, or in a few places upon the Fayetteville shale which underlies the Pitkin. The group is overlain unconformably by the Winslow formation. Both of these unconformities are more apparent to the north than toward the southern part of the area where the rocks are exposed. Indeed, in the Winslow quadrangle the beds apparently succeed one another with complete conformability. Farther north, however, the erosion intervals before and after the deposition of the group were more clearly recorded. In places the Pitkin limestone was entirely removed before the deposition of the Hale, while the variable thickness of the shales above the Brentwood horizon and the absence of the Kessler limestone in some places are attributable to the erosion which occurred before the grits and sandstones of the Winslow formation were accumulated.

The relations of the various formations of the region may be more easily understood if placed in tabular form.

Winslow formation, unconformity.

Morrow group.........	Bloyd shale, 100-220 ft. black carboniferous shale..	Kessler limestone lentil, 0-30 ft., near top. Coal seam, 0-14 inches. Brentwood limestone lentil, 10-50 ft., near base.
	Hale formation, 100-200 ft. Sandstone and shale with thin, local, limestone lenses.	

Unconformity. Pitkin limestone. Fayetteville shale.

Resume of Literature Concerning the Morrow Group

The first geological description of the strata under consideration seems to have been that of David Dale Owen in 1858.[1] He applied the terms "Archimedes limestone" to the Pitkin and "Millstone Grit" to the Winslow formations and described the coal seam of the Bloyd shale at various outcrops.

Two years later, accompanying Owen's second report, Lesquereux[2] published descriptions of the fossil flora which he had collected from the Morrow coal horizon and commented on its similarity to the flora from the coals above the Millstone Grit. He therefore included the shales of the Morrow in the "Arkansas Coal Measures."

A more detailed examination of the Morrow formations is recorded in the description of the Geology of Washington County by F. W. Simonds,[3] published in 1891. Here these formations are included with the Archimedes limestone and the Marshall shale [=upper part of Fayetteville shale] in the Boston group which is referred to the Chester, St. Louis, and Warsaw stages of the Lower Carboniferous or Mississippian series. The Hale formation is known as the Washington shale and sandstone, the Brentwood as the Pentremital limestone, and the Bloyd is called the Coal-bearing shale. Detailed descriptions of the numerous outcrops of these strata in Washington County are given.

In 1895, David White[4] stated that the flora of the "coal-bearing shale of Washington County, Arkansas, is largely identical with and clearly belonging to the Sewanee group of Tennessee." This reference of the Bloyd to the Pottsville stage seems to have been overlooked for, three years later, Drake[5] followed the classification of the Boston group used by Simonds in 1891 and mapped the Morrow formations with his "Lower

Carboniferous" in a reconnaissance of northeast Oklahoma. This report contains the first faunal lists from these formations, but unfortunately the fossils from the various horizons of the Boston group were not discriminated, the author stating that "most of the fossils came from the Archimedes [Mississippian] and Pentremital [Pennsylvanian] horizons."[6]

In 1898,[7] and again in 1900,[8] White repeated his statement concerning the Pottsville age of the coal-bearing shales of Washington County, Arkansas, and correlated the formation definitely with the Sewell formation of the Appalachian region.

In a description of the general geology of the Ozark region, published in 1901, Adams[9] described briefly the formations of the Morrow group, using Simonds's nomenclature and again referring the Boston group to the upper part of the Mississippian.

In 1904, the same author[10] in a discussion of the zinc and lead deposits of northern Arkansas described the Morrow as a variable formation embracing the Brentwood and Kessler limestone members and referred it to the Pennsylvanian series. Ulrich,[11] discussing in the same paper the correlation of the formations described by Adams, referred the Morrow to the lower Pottsville on the basis of the widespread unconformity at its base and the Pennsylvanian aspect of the fauna. A possible correlation with the Bend limestone and shale of central Texas was suggested and the question of the contemporaneity of the Morrow fauna with that described by Meek from "Old Baldy," Virginia City, Montana, was raised. It was stated that the marine faunas of early Pottsville times existed, perhaps without interruption, in basins to the southwest of northern Arkansas and thence periodically invaded the latter region.

The strata under discussion are mapped in the Fayetteville, Arkansas, quadrangle[12] as the Morrow formation, of early Pennsylvanian age, containing the Brentwood and Kessler limestone members. Its description and correlation are essentially the same as in the paper referred to in the last paragraph.

The Tahlequah, Oklahoma, quadrangle, adjoining the Fayetteville toward the southwest, was mapped by Taff.[13] The Morrow formation is considered as a stratigraphic unit and is stated to consist of three classes of rocks: the sandy strata at

the base, mapped as the Hale sandstone lentil, which decrease regularly in thickness toward the west until too thin to be mapped; the limestones of the middle part of the formation; and the shales with a few local beds of limestone, which also decrease toward the west, in the upper portion. The formation is placed at the base of the Pennsylvanian series and the suggestion is made that the Wapanucka limestone is probably the equivalent, in part at least, of the Morrow formation.

In 1905, Girty[14] published a brief discussion of the Morrow fauna and its relations to other mid-Carboniferous faunas. The presence of *Pentremites* and *Archimedes* above the Chester horizons was commented on and the Morrow was cited as the typical Pottsville fauna by comparison with which the age of many of the limestones of the west and southwest might be determined. Suggested correlations were made between the Morrow and the Carboniferous limestones of the Eureka District, Nevada, the Bend and Milsap of Texas, the Wapanucka of Oklahoma, and certain "lowest Pennsylvanian" formations of Colorado and New Mexico.

The Muscogee folio, also by Taff,[15] treats the Morrow in much the same way as does the Tahlequah folio as summarized in a preceding paragraph. In this quadrangle which adjoins the Tahlequah toward the west, the formation is composed largely of limestone with a variable amount of shale in the upper portion. It decreases irregularly in thickness toward the northeast and rests unconformably upon the Pitkin limestone. The unconformity at the top of the Morrow formation is stated to be greater than in the more eastern localities where the contact with the Winslow has been observed.

The last published folio of quadrangles in which the Morrow strata outcrop is that descriptive of the Winslow quadrangle,[16] situated south of the Fayetteville area. The two formations, the Bloyd and the Hale, as described in a preceding section of this report, are recognized as stratigraphic units composing the Morrow group. The faunas of the limestone horizons in the group are briefly discussed and the conclusion is stated that they are more closely related to well-known Pennsylvanian faunas than to any known fauna in the Mississippian series.

TABLE I.

THE MORROW FAUNA

Locality Nos.	Hale formation 136	137	139	149	Brentwood limestone 134	135	138	140	145	147	148	150	152	153	154	210	Kessler limestone 144	209	Morrow formation (undifferentiated in Oklahoma) 293	294	295	296	297	298	299	301	302	303	304	305	306	307	Hale formation	Brentwood limestone	Kessler limestone	Morrow formation (Oklahoma)
aphrentis gibsoni White					x	x							x			x		?				x										?		c	?	r
mplexus corrugatus n. sp.					x				x							x						x				x								c		c
ophophyllum profundum (M.-E. & H.)																										x										c
ampophyllum torquium (Owen)									x	x						x										x	x							c		r
nchypora carbonaria n. sp.									x							x						x	x			x								r		c
llichelinia eugeneae White						x			x	x			x				x					x		x	x	x	x			x				a	r	a
llichelinia oxilimura n. sp.																x							x									x				c
fichelinia subcylindrica n. sp.																										x										r
ulopora sp.																										x										r
ladochonus fragilis n. sp.																						x				x										a
haetetes milleporaceous M.-E. & H.																								x												r
entremites angustus Hambach	x	x			x	x		x	x	x			x	x												x							r	c		r
entremites rusticus Hambach																x								?		x				x		x		c		c
lydrcionocrinus sp.										x			x									x				x								r		r
romyocrinus graadis n. sp.									x																									r		
upachycrinus cf. magister Miller & Gurley					x								x			x						x				x								c		c
elocrinus dubius n. sp.					x	x								x								x				x								c		c
elocrinus pentanodus n. sp.																										x										r
elocrinus sp.																										x										r
tereobrachicrinus pustullosus n. sp.																						x				x										r
rcheocidaris sp.										x												x												r		r
istulipora sp.	x				x				x													x				x							r	c		c
tenopora tuberculata (Prout)					x																	x				x								r		c
tenopora sp.					x																													r		
nisotrypa sp.					x																													r		
enestella morrowensis n. sp.		x				x																x				x							r	r		r
enestella venusta n. sp.	x					x			x								x									x							c	c	r	c
enestella serratula Ulrich											x			x								x				x					x			c		c
rchimedes juvenis n. sp.											x			x								x												r		r
olypora anastomosa n. sp.	x					x						x																					c	c		
olypora anastomosa var. spinicarinata n. var.	x																																r			
olypora constricta n. sp.	x										x											x			x								c	r		r
olypora elliptica Rogers						x																				x								r		r
olypora halensis n. sp.	x																																r		r	
olypora kesslerensis n. sp.																		x																		
olypora magna n. sp.	x								x																								r	r		
olypora purduei n. sp.	x					x						x				x										x		x					c	c		c
olypora reversispina n. sp.	x																																r			
olypora washingtonensis n. sp.	x											x														x							c	r		r
olypora triseriata n. sp.	x					x			x		x	x																					c	a		
hyllopora cribrosa n. sp.																						x														r
hyllopora perforata n. sp.	x																																r			
eptopora crebripora n. sp.	x																																r			
eptopora implexa n. sp.					x																													r		
eptopora reversispina n. sp.									x																									r		
canthocladia sp.																						x														r
ictyocladia triseriata n. sp.	x					x																											r	r		
hombopora attenuata Ulrich																		x				x				x									c	a
thombopora lepidodendroides Meek																		x				x				x									c	a
thombopora snideri n. sp.																										x										c
thombopora tabulata Ulrich																						x				x										a
ystodictya brentwoodensis n. sp.	x					x					x																						r	c		
ystodictya flexuosa n. sp.																						x				x										c
ystodictya morrowensis n. sp.																						x				x										a
ystodictya sinuomarginata n. sp.	x					x																											r	r		
oscinium fayettevillensis n. sp.						x												x									x							r	r	r
oscinium gracilens n. sp.					x																						x							r		r
rismopora concava n. sp.																		x																	c	
lyptopora crassistoma n. sp.						x																x				x								r		c
rbiculoidea missouriensis (Shumard) ?																x																		r		
rhiculoidea minuta n. sp.	x				x																												r	r		
hipidomella altrirostris n. sp.			x																														r			
hipidomella pecosi (Marcou)														x		x										x								r		r
chizophoria resupinoides Cox	x		x	x	x	x										x	x	x			x				x	x	x	x	x		x		a	a	a	a
rthotetes robusta (Hall)	x	x		x	x	x								x			x	x													x		a	a	a	c
rthotetes ? sp.						x										x																		c		
eekella striatocostata (Cox)																	x																		r	
honetes arkansanus n. sp.																x												x	x					c		r
honetes chotcauensis n. sp.																					x					x										c
honetes laevis Keyes	x																									x							r			r
roductus cora d'Orbigny	x				x	x					?		x	x		x	x					x	x	x	x		x	x	x				r	c	r	a
roductus fayettevillensis n. sp.	x				x							x			x	x	x	x						x	x		x	x				x	c	a	a	a
roductus gallatinensis Girty	x	x					x				x			?				x		x				x					x				a	c	c	c
roductus nanus Meek & Worthen				x																								x	x				r			c
roductus morrowensis n. sp.	x			x		x	x	x	x	x		x			x	x	x	x	x			x	x	x	x		x			x	x	x	a	a	a	a
roductus welleri n. sp.	x				x	x		x	x	x		x	x	x	?	x		x		x					x			x	x		x	x	a	a	c	a
roductus sp.																		x																	r	
ustula hullata n. sp.									x				x																					c		
ustula globosa n. sp.											x					x									x			x						c		c
ustula nebraskensis (Owen)																x	x			x		?		x				x	x		x			c	c	c
ustula pertenuis (Meek) ?	x				x	x										x		x				x						x	x				c	c	c	c
ustula punctata (Martin)		x			x	x		x								x		x						x									c	a	c	c
ustula sublineata n. sp.													x																					c		
ugnoides triangularis n. sp.		x			x	x																									x		r	r		r
hynchopora magnicosta n. sp.						x						x																						r		
ielasma arkansanum Weller					x	x																												r		
ielasma bilobatum n. sp.					x	x																												r		
ielasma subspatulatum Weller	x	x			x	x	x	x				x	x			x		x		x								x	x				a	a	c	a
irtyella ? emarginata n. sp.																		x																	r	
pirifer goreii n. sp.	x																	x											x				r		r	c
pirifer opimus Hall					x							x	x					?											x	x				c	?	r
pirifer rockymontanus Marcou	x	x		x	x	x	x	x		x		x			x	x	x	x		x	x		x	x	x		x	x	x	x	x	x	a	a	a	a
rachythyris laticosta n. sp.																							x													r
quamularia perplexa (McChesney)	x			x	x	x	x	x			x					x		x		x				x				x					c	c	r	r
quamularia transversa n. sp.				x																													c			
piriferina campestris White	x				x	x				x						x	x					x	x		x	x	x			x	x	x	c	a	r	a
piriferina transversa (McChesney)	x	x		x	x	x		x									x	x				x					x					x	c	a	c	a
ustedia brentwoodensis n. sp.	x				x	x										x										x	x			x		x	c	a		c
ustedia miseri n. sp.	x	x		x	x	x		x						x		x		x								x	x	x	x		x		c	c	c	c
umetria vera (Hall)											x		x	x																				r		
omposita biplicata n. sp.																			x							x										r
omposita deflecta n. sp.					x	x																				x								c		r
omposita gibbosa n. sp.				x		x							x															x	x			x	r	c		c
omposita ovata n. sp.	x		x	x		x											x	x			x						x						a	c	a	c
omposita ozarkana n. sp.	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x			x			x			x	x	x	x	x	x	x	a	a	c	a
omposita transversa n. sp.		x									x		x																				r	c		
omposita wasatchensis (White)	x			x	x	x			x		x		x	x		x		x		x			x			x	x	x	x	x	x	x	a	a	c	a
olenomya sp.																	x																		r	
phenotus halensis n. sp.	x																																r			
dmondia maccoyii Hind ?																		x																	r	
dmondia subtruncata Meek																		x																	r	
ucula kessleriana n. sp.																		x																	r	
ucula parva McChesney		x																															r			
ucula sp.																		x																	r	
eda bellistriata Stevens ?	x	x																															c			
arallelodon cancellosus n. sp.						x																									x			r		r
arallelodon pergibbosus n. sp.						x																												r		
arallelodon sangamonensis (Worthen)																		x																	r	
ypricardinia laevicula n. sp.						x																												r		
lonopteria ? sp.	x																											x					r			r
seudomonotis inflata n. sp.																		x																	r	
seudomonotis precursor n. sp.						x																												r		
lyalina cuneiformis Gurley ?																		x																	r	
lyalina orthonota n. sp.	x	x		x													?														x		a		?	r
lyalina recurvirostris Meek & Worthen	x																																c			
chizodus morrowensis n. sp.	x																																r			
viculopecten arkansanus n. sp.	x																	x															c		r	
viculopecten auriseulptus n. sp.	x																																r			
viculopecten halensis n. sp.	x																																r			
viculopecten hertzeri Meek																	x																		r	
viculopecten talboti Worthen ?	x																																r			
viculopecten sp.																		x																	r	
viculopecten ? cf. interlineatus Meek & Worthen						x																												c		
eltopecten occidentalis (Shumard)	x																	x															c		c	
alaeolima inequicostata n. sp.																		x																	r	
leurophorus tropidophorus Meek	x																																r			
epetopsis chesterensis Worthen ?		x																															r			
epetopsis sp.																		x																	r	
ellerophon crassus var. wewokanus Girty					x																													r		
ellerophon cf. sublaevis Hall	x					x																														
uphemus carbonarius (Cox)		x				x														x							x					x	c	c		c
orthenia tabulata (Conrad)																		x															r	r		
uconospira arkansana n. sp.					x	x																													r	
traparollus cf. spergenensis Hall																x											x							c		r
uomphalus catilloides (Conrad)			x						x																		x							r		c
trophostylus subovatus (Worthen) ?	x																									x							r	r		r
latyceras parvum (Swallow)		x		x		x																											r			
clisina ? sp.	x				x	x										x		x	x		x						x	x			x		c	c	c	c
leekospira ? sp.						x												x		x													r	r	r	r
phaerodoma sp.						x																				x								r		r
rthoceras sp.						x																					x							r		r
astrioceras branneri Smith				x																								x						c		r
astrioceras kesslerense n. sp.																						x											r			r
astrioceras pygmaeum n. sp.					x	x												x									x								r	r
riffithides morrowensis n. sp.	x	x		x		x	x				x			x		x		x		x				x	x		x	x			x		c	c	c	c
riffithides ? sp.																x																		r		
etalodus sp.	x																																r			
eltodus ? sp.																																	r			
																												x								r

TABLE II

Chart showing the Range of the Faunules composing the Morrow fauna.

The figures represent the number of species having the range indicated by the position of the figures in the columns. For example, 22 species in the Hale faunule do not occur in the Brentwood or Kessler horizons and of that number 4 are present in the Morrow of Oklahoma; 20 species are common to the Hale and Brentwood but are not found in the Kessler, and of that number 11 are present in the Morrow of Oklahoma.

Hale Formation	Brentwood Limestone	Kessler Limestone	Morrow Formation (undifferentiated in Oklahoma)
22	....	....	4
20	20	...	11
4	....	4	2
22	22	22	22
...	44	...	25
...	5	5	5
...	....	21	3
...	....	...	19
Totals 68	91	52	91

Schuchert,[17] in 1910, ascribed an early Pottsville age to the Morrow fauna which is stated to be largely new. Similarities are noted between it and the fauna listed by Meek from "Old Baldy" near Virginia City, Montana, which "in the light of the Arkansas collections . . . must now be referred to the Pottsvillian."

Ulrich[18] concurs in the reference of the Morrow to the early Pottsville. He states also that the Caney shale, of the Ouachita geosyncline, "is in part represented by the upper black shale of the Morrow group in northern Arkansas."

In the Index to the Stratigraphy of North America, Bailey Willis[19] gives a brief review of the literature concerning the Morrow formations and in his correlation table places the group at the base of the Pennsylvanian series.

The Morrow Fauna

From the material upon which these studies are based 158 species have been identified and are discussed in the following pages. Seventy-nine of these are here described for the first time; twenty-two others have been referred to genera, six of them questionably, but on account of their fragmentary condition or poor preservation have not been given specific names though most of them probably represent undescribed forms.

The fauna is composed of the following forms of animal life: corals, 9 genera and 11 species; blastoids, 1 genus and 2 species; crinoids, 5 genera and 7 species; echinoids, 1 genus and 1 species; bryozoans, 15 genera and 38 species; brachiopods, 20 genera and 48 species; pelecypods, 16 genera and 29 species; gastropods, 12 genera and 14 species; cephalopods, 2 genera and 4 species; trilobites, 1 genus and 2 species; fishes, 2 genera and 2 species.

The complete faunal list is presented in Table I.

Faunal Horizons

In the eastern part of the Morrow basin, corresponding roughly to the portion east of the Arkansas-Oklahoma boundary, three distinct horizons of fossiliferous limestones have been recognized. These are separated by variable, but in most places not great, thicknesses of non-fossiliferous sandstones and shales, the interval between the upper two of the three also including a thin seam of coal. The question of the similarity or difference

between the three faunules will at once come to mind. A study of the range of the different Morrow forms, as summarized in Table II, makes it quite clear that the life-assemblage of each of these horizons was distinct from that of the other two although the three have a common aspect.

Doubtless the absence of certain of the more rare forms from a horizon is more apparent than real as it cannot be supposed that every form of life which composed a faunule has found a place in the collections upon which these studies are based. It is probably significant that eighteen of the twenty-two species which have been recorded as ranging throughout the entire Morrow group are brachiopods, by far the most important numerically of all the classes of life represented and hence the least likely to escape collection. On the other hand, the fact that only four species are known from the lower and higher horizons without also being recorded from the intermediate one would indicate that our knowledge of the faunules is not seriously incomplete.

Not only does the distinctive nature of the individual faunules appear from the statistical method of comparison but it is also clearly indicated by a comparison of the types of life present or absent as the case may be. For example, the genera, *Pentremites* and *Archimedes,* which are of a decided Mississippian aspect and are represented by forms which have lingered on into Pennsylvanian times, do not range above the Brentwood limestone, while certain of the typically Pennsylvanian types such as *Campophyllum* and *Pseudomonotis* do not appear beneath that horizon. *Meekella, Worthenia,* and several other Pennsylvanian forms are not introduced until the deposition of the Kessler limestone.

As has been pointed out on a preceding page, the character of the Morrow sediments changes notably toward the west and throughout most of the Oklahoma region the strata have been mapped as a single formation. Limestone is the dominant rather than the subordinate type of rock and the whole series thins markedly toward the west and northwest although the limestone is somewhat thicker than either of the limestone members of the Bloyd shale. The question suggests itself as to the exact relations of the western limestone to the limestones

and clastics of the eastern portion. Does the Morrow of Oklahoma represent there the entire series as developed in Arkansas, or is it due to the westward spread of the Morrow seas during one of the three intervals of deeper water implied by the formation of the limestone lenses in the midst of the clastic deposits in the eastern basin which presumably was adjacent to the higher lands from which the sediments were derived?

From the undifferentiated Morrow of Oklahoma ninety-one species have been identified and all but nineteen of them are forms which occur also in the various horizons of the group in Arkansas. The relations of this fauna to the three Arkansas faunules is shown in column 4 of Table II. The evidence points to the equivalence of the Morrow limestone of Oklahoma and the Brentwood limestone member of the Morrow group in Arkansas.

Analysis of the Morrow Fauna

A critical examination of the Morrow fauna makes evident its position as transitional between the faunas which have been considered typical of the later Mississippian and of the earlier Pennsylvanian times. The reference of the Morrow group to the early Pottsville, which has been made on the basis of the flora occurring in the Bloyd shale between the Brentwood and Kessler members, appears to be verified by the faunal evidence from the associated limestones. The fauna is essentially a mingling of two assemblages of animals, one group composed of forms of a Mississippian type which had persisted in basins to the south to which they had retreated with the withdrawal of the Chester seas from the Mississippi valley region, and the other including those forms which are typical of the Pennsylvanian period and either had evolved in the southern basin after the Chester retreat or had invaded the Morrow seas at or before the time of advance into the Arkansas-Oklahoma locality. The former may be conveniently referred to as the *residual* element and the latter as the *proemial** element.

Among the corals, the subclass *Tetracoralla* is represented by four species belonging to four of the more common Carbonifer-

*J. M. Clarke has applied the term "proemial" to "an introductory fauna which heralds the incoming of a new organic association and passes gradually, without interval or interruption, into that culminant assemblage."[20]

ous genera. *Zaphrentis gibsoni* is probably the only species of that genus which is recorded from the Pennsylvanian strata although the genus is quite abundant in the Mississippian rocks. It is known to occur in the Coal Measures of Indiana and the Pennsylvanian limestone of Colorado. The genus *Amplexus*, represented in the Morrow fauna by a new species, is rarely present in North America above the Mississippian beds as it has heretofore been reported only from scanty fragments in the Hermosa and Weber limestone of Colorado, the Lower Aubrey of Utah, and from the Guadalupian terranes. *Lophophyllum profundum* and *Campophyllum torquium* are widespread throughout the Coal Measures of the Mississippi valley and both occur in the Pennsylvanian limestones of the west. The latter genus is not reported from the Mississippian formations of North America but the former is present in the Keokuk and Chester beds. Both species have a long range above the Morrow, the former persisting to the uppermost of the Pennsylvanian formations of Kansas and the latter disappearing only above Stage G of that section, as reported by Beede and Rogers.[21]

The favositid tabulate corals include a new species of *Pachypora* and three species of *Michelinia*, only one of which was heretofore known. *Pachypora* is abundant in Silurian and Devonian formations but has not been heretofore reported from the later Paleozoic rocks of North America. It occurs, however, in the Productus limestone of the Salt Range and probably elsewhere in Europe and Asia. The genus is also represented in the Fayetteville shale of Oklahoma by a single species, quite distinct from that found in the Morrow.[22] *Michelinia eugeneae* is present in the Coal Measures of Indiana, Illinois, and Kansas and in the last named state is restricted to the two lower series of the four into which the Pennsylvanian rocks are divided. The genus is recorded as occurring frequently in the Mississippian strata.

Associated with these forms are three other tabulate corals, *Aulopora sp.*, *Cladochonus fragilis*, and *Chaetetes milleporaceous*. The first named genus is quite common throughout the Carboniferous rocks of North America but the second is represented by only two species besides the one here described. One of these occurs in the Fern Glen formation while the other is found in

the Cherokee shales at the base of the Kansas Pennsylvanian series. *Chaetetes* is abundant throughout the world in the later Paleozoic limestones and the form here recorded is known from the Coal Measures of Tennessee, Missouri, and Kansas as well as from the Pennsylvanian limestones of several western states.

Blastoids are represented in the Morrow fauna by two species of *Pentremites,* a genus which has been supposed to occur only in Mississippian strata. The individuals of the genus are so numerous in the Brentwood member that this formation was termed the Pentremital limestone by the geologists of the earlier Arkansas Survey. The genus is present, though rare, in the Hale formation but is not known from the Kessler. This association of the genus with forms of Pennsylvanian age which also occur in the Brentwood limestone is unique.

Crinoids are abundantly indicated by the numerous fragments of stems and plates which contribute to the limestones of the group but are only rarely preserved with sufficient completeness to afford an opportunity to determine their affinities. *Hydreionocrinus* is represented by a few plates which offer no clue as to specific relationships. The genus is present throughout the Carboniferous terranes. *Cromyocrinus,* represented by a new species, has been previously reported in North America only from Mississippian formations while the species of *Eupachycrinus* most strongly suggested by the isolated plates which are referred to that genus is present in the Coal Measures of Missouri. *Delocrinus* is represented by three species here described for the first time. This genus has been identified only from the post-Chester formations with the possible exception of a little crinoid from the Kaskaskia of Tennessee which is doubtfully referred to it by Rowley. *Stereobrachicrinus* is a new genus provisionally referred to the *Poteriocrinidae,* the most common of the families of Carboniferous crinoids.

The presence of echinoids in the Morrow seas is recorded by a few of the spines characteristic of *Archeocidaris,* a genus which ranges throughout the entire Carboniferous series.

Bryozoans make up a large proportion of the Morrow fauna and are especially abundant in the limestone lenses of the Hale formation. The *Cyclostomata* are represented by an undetermined species of *Fistulipora,* a genus which is quite common in

Mississippian but less numerous in Pennsylvanian rocks. The *Trepostomata* are somewhat more abundant, with two species of *Stenopora* and one of *Anisotrypa.* Of the three only one, *S. tuberculata,* is identified specifically. It is a form which frequently occurs in the St. Louis and Chester horizons of the central states and has been reported from the Pennsylvanian of Nebraska and Colorado. The second of these two genera has not heretofore been described from beds younger than the Chester.

By far the larger percentage of the Morrow bryozoans belong to the order *Cryptostomata* and the family *Fenestellidae. Fenestella* is represented by three species, two of which are new, and the third, *F. serratula,* recorded as ranging from the Keokuk to the Chester in the Mississippi valley, has not been previously known to persist into Pennsylvanian times. The highly specialized genus, *Archimedes,* represented by a new species, is occasionally found in the Brentwood horizon. Like *Pentremites,* it has been supposed to be diagnostic of Mississippian times. Four species of the genus, however, occur in the Timan Mts. in the Schwagerina zone, the uppermost of the Carboniferous limestones of Russia,[23] and it has been reported[24] in the Lower Aubrey limestone of the Uinta Mountains associated with an Upper Carboniferous fauna. Girty, also, states[25] that he has collected the genus in abundance in the Bingham district, Utah, in rocks which he believes to be of Pennsylvanian age. Eleven species of *Polypora,* all new but one, have been distinguished. *P. elliptica* is present throughout the Coal Measures of Missouri, Kansas, and Nebraska, ranging from the Ft. Scott to the Neva limestone in Kansas. The genus *Phyllopora* has heretofore been reported from strata younger than the Devonian at only one locality in North America. It is stated[26] to occur in the Embar formation, probably of Permian age, in Wyoming and has been described from occurrences in late Paleozoic rocks in Great Britain and India. Two species, both undescribed, are here referred to the genus.

The family *Acanthocladiidae* is represented by five forms, three new species of *Septopora,* a genus present in both Mississippian and Pennsylvanian times, an *Acanthocladia,* and a species referred to a new genus to which the name *Dictyocladia* is

given. *Acanthocladia* is not known to occur below the Pennsylvanian strata.

The genus *Rhombopora* is very abundant in the mid-Carboniferous limestones, especially those that are somewhat arenaceous. Two of the Morrow species, *R. attenuata* and *R. tabulata*, are typical Mississippian forms, characteristic of the Keokuk and Chester horizons, which have not previously been observed in Pennsylvanian rocks. *R. lepidodendroides*, on the other hand, is typical of the Coal Measures through which it ranges in great abundance and has been identified from the Molas and Hermosa limestones of Colorado. The fourth member of this genus is a new species with indefinite affinities.

The remaining bryozoans belong to the family *Cystodictyonidae*. *Cystodictya* is represented by four new species whose relationships are about as close to the members of the genus occurring in the earlier Carboniferous as to those in the later. Two species of *Coscinium* have been identified, both of them new. This genus has not been reported from the Pennsylvanian of North America and occurs very sparingly in Mississippian, although more abundant in Devonian, formations. It was, however, first described by Keyserling[27] from two species noted as occurring in the "Bergkalk" of the Timan Mts. The limestones from which they were obtained, in association with *Fusulina*, are described[28] as overlying others in which *Spirifer mosquensis* and *Chaetetes radians* are the characteristic fossils. They are therefore to be correlated with the middle or upper Pennsylvanian rocks of North America. Tschernyschew[23] also cites three species of the genus in his faunal list from the Schwagerina zone in the Timan Mts. *Prismopora* and *Glyptopora* are each represented by a new species. The former genus is known to range throughout the Carboniferous strata but the latter has heretofore been reported only from Mississippian formations.

The Morrow fauna is in large degree a brachiopod one, not because of the abundance of brachiopod species but because of the great numbers of individuals of nearly every species of this class. No representatives of the *Atremata* occur here and the *Neotremata* are very scantily represented by two species of *Orbiculoidea*. *O. missouriensis* is a common form in the Coal Measures of the central states, occurs in the Park City forma-

tion of Utah and Idaho, and is present in the late Pottsville Mercer limestone of Ohio. In Kansas it ranges throughout the entire Pennsylvanian section. The other species is a new one with indefinite affinities.

The *Protremata* are far more abundant. *Rhipidomella* is represented by two species, one of which, *R. pecosi*, is the only species of this genus heretofore recorded from the Pennsylvanian of North America. It occurs throughout the Coal Measures of the Mississippi valley as well as in several of the Upper Carboniferous limestones of the west. *Schizophoria resupinoides* is present in great numbers. This form, probably a descendant of the Mississippian *S. resupinata*, has been described from the Coal Measures of Kentucky, Illinois, and Arkansas, and occurs in the Carboniferous limestones of New Mexico. *Orthotetes* ranges throughout the Carboniferous strata of North America. One of the two Morrow species referred to it is *O. robusta*, a form common in the Coal Measures of Illinois, Iowa, and Missouri, and occurring in the Ames limestone, of Conemaugh age, in Pennsylvania. *Meekella striatocostata* is commonly present throughout the Coal Measures of the central states and has frequently been identified from the Pennsylvanian limestones of the west. The genus is unknown in Mississippian rocks.

The *Productidae* are present in the abundance and diversity ordinarily found in the later Paleozoic faunas. *Chonetes laevis* which has frequently been confounded with *C. geinitzianus* is apparently a valid species which seems to be confined to the earlier Pennsylvanian rocks and is replaced in the middle portion of the system by the form with a distinct sinus with which it has been confused. It occurs in the Cherokee shales at the base of the Kansas Pennsylvanian and in the Lower Coal Measures of Iowa. Two other species of this genus are here described for the first time.

Productus, as restricted by Thomas,[29] includes seven of the Morrow forms, only three of which have been previously known. The form identified as *P. gallatinensis* is certainly conspecific with the fossils from the Hermosa limestone of Colorado to which Girty has applied that name and it is closely related to, if not identical with, *P. boonensis* described by Swallow but never illustrated, from the Coal Measures of Nebraska and Kansas.

Girty's name was first applied to a *Productus* from the Madison limestone, of Mississippian age, in Yellowstone National Park. *P. cora* is a form which ranges throughout the Mississippian and Pennsylvanian terranes of North America in great abundance and with little or no variation. It occurs also in the Upper Carboniferous of South America and Eastern Europe so that its distribution is as great as its range. *P. nanus* is known from the Lower Coal Measures of Iowa.

The genus *Pustula* includes those members of the older genus *Productus* whose ornamentation is essentially spinose rather than costate. Six species, three of which are new, have been referred to it. *P. nebraskensis,* one of the most characteristic of Pennsylvanian brachiopods, ranges throughout the Coal Measures of the Mississippi valley and is present in the western Upper Carboniferous limestones. *P. pertenuis* is found in the Coal Measures of Nebraska, Oklahoma, and Kansas, and in the last-named state ranges from Stage B to Stage G of Beede and Rogers's section. It has been questionably identified from the Hermosa of Colorado. The material at hand is probably not quite typical but is certainly very closely related to the Coal Measures forms. *P. punctata* has a distribution similar to that of *P. nebraskensis* but apparently was not so perseverant a form as it is not known in Kansas above the Burlingame limestone in Series III; it is probably a descendant of the Mississippian *P. alternata.*

The *Telotremata* include half of the Morrow brachiopods. Two of the forms are rhynchonelloids, *Pugnoides triangularis* and *Rhynchopora magnicosta,* both new species. The former genus is represented in Mississippian strata by several forms but is known to include only one other Pennsylvanian brachiopod, *P. uta* (Marcou). *Rhynchopora* likewise is more abundant in Lower than in Upper Carboniferous strata and only two other species have been referred to it from the later series.

Terebratuloids are much more abundant. *Dielasma arkansanum* and *D. subspatulatum* were originally described by Dr. Weller from collections made in Washington County, Arkansas; at that time their stratigraphic position was not definitely known. The former is very rarely present in the Morrow formations and has been identified by the writer from the Fayetteville shale,

in which it occurs in abundance in the vicinity of Prairie Grove and elsewhere in northwest Arkansas. The latter species is not known to occur beneath the Hale formation and is one of the most characteristic of all the Morrow brachiopods, being present in great numbers in each of the fossiliferous horizons of the group. A third species of *Dielasma,* not previously known, is associated with these two. Another small *Dielasmatinae* represents a new species and probably a new genus. It is here referred to *Girtyella,* a genus known at present only from Mississippian strata, as it appears to be most closely related.

The *Spiriferidae* include some of the most characteristic and abundant species of the fauna. *Spirifer* is represented by three species. *S. opimus,* long relegated to the synonomy of the next-named form but believed to be a distinct species, is known from the Coal measures of Ohio and Iowa, while *S. rockymontanus* has a wide distribution in the Pennsylvanian limestones of the west. In the Mississippi valley, where it has been reported from the Coal Measures of half a dozen states, it seems more characteristic of the lower than of the upper portion of the series. In Ohio and Pennsylvania it occurs in the Mercer and Vanport limestones. *S. goreii,* a new species, is suggestive of *S. striatus* of the Mississippian and may be closely related to it. *Brachythyris,* represented here by a newly described form, has not been previously reported from post-Chester strata in North America but it is noteworthy that several of the spirifers described by Tschernyschew from the Upper Carboniferous of the Ural and Timan Mountains are apparently to be referred to this genus which many consider to be a subgeneric group under *Spirifer. Squamularia perplexa* is fairly abundant in the Morrow and has much the same distribution and range as *Spirifer rockymontanus.* In the Kansas section it is restricted to Stages A to G, not occurring in Series IV at the top of the system. Associated with it is a larger undescribed form. The genus is characteristic of the Pennsylvanian and is not known to occur in the Mississippian formations of this continent.

Spiriferina is represented by two species, *S. campestris,* typical of the Pennsylvanian of the west and southwest, and *S. transversa,* a Chester form, reported from the Coal Measures of Brazil and apparently replaced in the mid-Pennsylvanian seas

by the closely related *S. kentuckiensis*. Two species of *Hustedia*, both new, are present in great abundance. The genus is sparingly represented in the Mississippian faunas but becomes of much greater numerical importance in the Pennsylvanian. Associated with it are a few individuals indistinguishable from *Eumetria vera*, a typical Chester form and a member of a genus which has not heretofore been known from the Pennsylvanian rocks of America.

Athyrids are represented by seven species of *Composita*, some of which are present in great numbers. Only one of these, *C. wasatchensis*, is known to occur elsewhere although two others are closely related to common Carboniferous types. White's species was described from the Upper Carboniferous of Utah but it is similar to, if not identical with, a Madison limestone form to which Girty has applied the name *C. humilis*.

Pelecypods form a considerable element in the Morrow fauna although they are not nearly so abundant as is generally the case among Pennsylvanian invertebrates. Ordinarily a species is represented in the collections at hand by less than a half dozen individuals while among the brachiopods there are scores of individuals of nearly every species. *Solenomya*, a genus about as abundant in the Mississippian as in the Pennsylvanian, is represented by a single species of doubtful affinity. *Sphenotis halensis* is a new species of this genus which like its near relative, *Sanguinolites*, is with this exception confined, so far as reported in North America, to Mississippian rocks. Two species of *Edmondia* have been identified. One is referred with a query to a species which ranges in England, as reported by Hind, from the Lower Carboniferous into the Millstone Grits. The other, *E. subtruncata*, is characteristic of the Coal Measures of the Mississippi valley and has been identified from the Hermosa of Colorado.

Nucula is represented by three forms, only one of which is known to occur elsewhere. *N. parva* is a typical Pennsylvanian pelecypod occurring in the Coal Measures of the Mississippi valley and with a considerable range, as it is known from the Mercer (Late Pottsville) of Ohio, the Ames and Brush Creek (Conemaugh) of Pennsylvania, and the Drum limestone (Stage D) of Kansas. *Leda bellistriata* has a similar distribution and

range east of the Mississippi River, ranges from Stage B to Stage G in Kansas, and is known from the Cordilleran region as well. It has, also, been reported in the Waverly formations of Tennessee and in the Marshall of Michigan.

Parallelodon sangamonensis is a typical mid-Pennsylvanian pelecypod occurring in the Mercer and Brush Creek limestones, the Coal Measures of Illinois and Missouri, and ranging in Kansas from Stage C to F. It is accompanied in the Morrow by two new species of the same genus whose affinities with forms in either higher or lower horizons are not marked. *Cypricardinia* is represented by a new form with similar indefinite affinities.

The *Myalinas* are numerically the most important pelecypods of the fauna. *M. cuneiformis* is known elsewhere only from Pennsylvanian limestones of Colorado, *M. orthonotis* is a new species, and *M. recurvirostris* is frequently found in the Coal Measures of the central states, ranging from Stage D to F of the Kansas section. *Schizodus,* a genus which although present in all Carboniferous horizons is most abundant in Permian formations, is represented by a new species.

The pectens are an essential element of the pelecypod fauna of the Morrow, as is usually the case in Carboniferous faunas. In addition to several new species, four well-known ones have been identified. *Aviculopecten hertzeri* and A.? *interlineatus* are typical Pennsylvanian types recognized in the Cordilleran as well as the interior provinces. *A. talboti,* on the contrary, is a Ste. Genevieve limestone form with which the Morrow individuals are closely related if not conspecific. *Deltopecten occidentalis* has a wide distribution and long range in the Pennsylvanian terranes of this continent.

Monopteria and *Pseudomonotis* are not known to occur below the Pennsylvanian in North America. The former is doubtfully represented by a fragmentary individual in the Morrow while to the latter genus are referred two new species. Another undescribed form is referred to *Paleolima,* a genus fairly abundant in the Carboniferous of England. *Pleurophorus tropidopherus* is a typical Pennsylvanian form which ranges from Stage C to H of the Kansas section and occurs in the Mercer of Ohio as well as in the Coal Measures of Missouri.

Gastropods are not plentiful in the Morrow fauna but like the other classes of invertebrates they show conspicuously a mingling of Mississippian and Pennsylvanian types. *Lepetopsis chesterensis,* as its name implies, is a typical Chester form and the individual found in the Morrow presents little or no variation from the earlier ones. *Bellerophon crassus* var. *wewokanus* is known from the Wewoka limestone, a mid-Pennsylvanian formation of Oklahoma, and from the Ames and Brush Creek limestones in West Virginia. The typical variety of the species is present in nearly all collections from the Coal Measures. The smaller *Bellerophon,* compared with *B. sublaevis,* is very closely related to that common Mississippian form. *Euphemus carbonarius* ranges throughout the entire Kansas section and is characteristic of the Pennsylvanian of the Mississippi valley region.

Worthenia tabulata is likewise a Pennsylvanian form with a wide distribution and long range. *Euconospira* is abundant in the Pennsylvanian formations but is known in Mississippian beds from only one species which occurs in the Fayetteville shale. It is represented in the Morrow by a new form.

Straparollus is represented by a number of individuals which are very closely related to *S. spergenensis,* an Upper Mississippian species, while *Euomphalus catilloides* is another fossil characteristic of Pennsylvanian strata in which it has a long range and wide distribution. *Strophostylus subovatus* occurs in the Coal Measures of Illinois and the Hermosa limestone of Colorado. The single individual from the Morrow is referred to it with little doubt as to the correctness of the identification. *Platyceras parvum* is the most abundant of the Morrow gastropods. It occurs in the Coal Measures of the Mississippi valley quite generally and is reported from certain of the Pennsylvanian limestones of the west.

Three of the Morrow gastropods are turreted shells. *Aclisina* and *Sphaerodoma* range throughout the Carboniferous while *Meekospira* is apparently confined to Pennsylvanian formations. All three are very scantily represented in the fauna.

Cephalopods are comparatively unimportant numerically but the four forms identified are of considerable interest. The species of *Orthoceras* resembles certain of the Mississippian members of that genus as closely as it does the Pennsylvania forms.

Gastrioceras is represented by three species none of which is known to occur elsewhere though one, *G. branneri*, was described several years ago by Smith. The genus appears to be especially characteristic of the mid-Carboniferous times.

Trilobites are represented by numerous pygidia which might as well belong to species of *Phillipsia* as of *Griffithides*, and by two types of glabella, both belonging to the latter genus. Affinities with other trilobite species are not conspicuous.

Summarizing the foregoing paragraphs, it appears that the transitional aspect which characterizes the Morrow fauna is displayed in greater or less degree by each of the classes of invertebrates which compose it. The following list includes the most typical of the forms representing the residual Mississippian element:

Residual Mississippian Element of the Morrow Fauna

Amplexus corrugatus
Pentremites angustus
Pentremites rusticus
Cromyocrinus grandis
Stenopora tuberculata
Anisotrypa sp.
Fenestella serratula
Archimedes juvenis
Rhombopora attenuata
Rhombopora tabulata
Glyptopora crassistoma
Dielasma arkansanum
Brachythyris laticosta
Spiriferina transversa
Eumetria vera
Sphenotus halensis
Aviculopecten talboti?
Lepetopsis chesterensis?
Bellerophon cf. sublaevis
Straparollus cf. spergenensis

In contrast with the residual element the forms listed below may be cited as representatives of the proemial Pennsylvanian facies. Those not included in the two lists are of indefinite affinities or of little value, in the present state of knowledge, as indicators of time relations.

Proemial Pennsylvanian Element of the Morrow Fauna

Zaphrentis gibsoni
Lophophyllum profundum
Campophyllum torquium
Michelinea eugeneae
Chaetetes milleporaceous
Eupachycrinus cf. magister
Delocrinus dubius
Delocrinus pentanodus
Delocrinus sp.
Polypora elliptica
Squamularia perplexa
Squamularia transversa
Spiriferina campestris
Hustedia brentwoodensis
Hustedia miseri
Edmondia subtruncata
Nucula parva
Leda bellistriata?
Parallelodon sangamonensis
Myalina cuneiformis?

Acanthocladia sp.
Rhombopora lepidodendroides
Orbiculoidea missouriensis?
Rhipidomella pecosi
Schizophoria resupinoides
Orthotetes robusta
Meekella striatocostata
Chonetes laevis
Productus nanus
Pustula nebraskensis
Pustula pertenuis?
Pustula punctata
Spirifer opimus
Spirifer rockymontanus
Platyceras parvum
Myalina recurvirostris
Aviculopecten hertzeri
Aviculopecten? cf. interlineatus
Deltopecten occidentalis
Monopteria? sp.
Pseudomonotis precursor
Pseudomonotis inflata
Pleurophorus tropidophorus
Bellerophon crassus var. wewokanus
Euphemus carbonarius
Worthenia tabulata
Euomphalus catilloides
Strophostylus subovatus?
Meekospira? sp.

It has been suggested above that a progressive disappearance of the earlier type and an increasing ingress of the proemial facies of the fauna may be observed by a comparison of the three horizons of fossiliferous limestones. The question may be raised as to the propriety of placing the Mississippian-Pennsylvanian boundary beneath the Hale formation rather than above the Brentwood limestone with its *Pentremites* and *Archimedes* and beneath the coal horizon with the Pottsville flora. Noting, however, the stratigraphic position of the forty-nine species listed above as indicative of Pennsylvanian age, it is observed that twenty-two of them are recorded from the Hale formation, comprising nearly one-third of the Hale faunule, and twenty-five have been identified from the Brentwood horizon. The faunal evidence therefore confirms the stratigraphic evidence in favor of considering the whole Morrow group as a unit and recognizing the unconformity at its base as marking the beginning of the Pennsylvanian period.

Faunal Correlations

In searching for the homotaxial equivalents of the Morrow fauna it seems useless to look to the portion of North America north and east from the Morrow locality. Throughout the eastern and northern portions of the Mississippi valley the basal Pennsylvanian rocks are either much younger than the Morrow or were deposited under non-marine or brackish-water conditions which precluded the entrance of a marine fauna. In the

Appalachian trough where the plant remains indicate deposition during earlier Pottsville times the latter was the case.

In Ohio the Mercer limestone occurs not far above the Mississippian-Pennsylvanian unconformity but the Sharon coal which underlies it has been referred to the Upper Pottsville on the evidence of the associated flora so that the oldest Pennsylvanian beds in this region are younger than the Morrow. The fauna of the Mercer has been described by Miss Mark.[30] It contains seventy-two species, over half of which are pelecypods, and includes seventeen of the species which have been described from the Morrow, in addition to a half dozen other forms closely related to certain of the Morrow species. These seventeen are among those forms noted in the preceding section as ranging upwards well towards the top of the Pennsylvanian system. The Mercer fauna is essentially a molluscan one with few brachiopods and fewer bryozoans. It contains nothing suggestive of the Mississippian faunas, or a transition therefrom, and is evidently younger than the Morrow.

The study of the faunal horizons of the Pennsylvanian of Kansas made by Beede and Rogers[21] affords the best information available at present as to the earlier Coal Measures faunules. Those authors divide the system as present in Kansas into ten stages lettered from A to J, grouped in four series. Included in the faunal list of four hundred Pennsylvanian forms which have been identified from that state are twenty-five of the Morrow species. Most of them are shown to have a long range throughout the various stages. Ten are present in the Cherokee shales, Stage A, Series I; the same number are introduced in the overlying Ft. Scott limestone at the base of Stage B, Series I. The remaining five are all present before the top of the Drum limestone, Stage D, Series II, is attained. A comparison of the fauna of the Cherokee shale with that of the Morrow group makes it clear that the former is much younger than the latter as it, like the Mercer, contains nothing suggestive of a transition from the Mississippian.

In western North America conditions are much more favorable for finding the record of a marine fauna contemporaneous with the Morrow, for in that region deposition not only began much earlier than in the northern and eastern Mississippi valley

area but there the seas were in many localities clear and hospitable to life from the beginning of the period. Two faunas from the Cordilleran region bear rather striking resemblances to the Morrow fauna.

One of these was described in 1873 by Meek[31] from collections made at "Old Baldy" near Virginia City, Montana. Both Ulrich and Schuchert have pointed out the similarities which apparently exist between the Old Baldy fauna with its *Pentremites, Eumetria,* and other forms of a Mississippian aspect associated with *Squamularia* and other Pennsylvanian types, and the Morrow fauna. Further study of the Montana faunas may prove that certain of the Carboniferous limestones of that state are of early Pottsville age.

Fully as significant a resemblance exists between the Morrow fauna and that of the Lower Aubrey group described by White[32] from collections made by the Powell Survey in the vicinity of the Uinta Mountains in Utah. The following list with the comparisons appended shows the similarity of the faunas:

Lower Aubrey Fauna		*Morrow Fauna*
Chaetetes milleporaceous	ibid.	
Fistulipora sp.	cf.	Fistulipora sp.
Syringopora sp.		
Amplexus zaphrentiformis	cf.	Amplexus corrugatus
Lophophyllum proliferum	=	Lophophyllum profundum
Lithostrotion sp.		
Acervularia sp.		
Archeocidaris cratis	cf.	Archeocidaris sp.
trudifer		
Erisocrinus typus	cf.	Delocrinus dubius
Scaphiocrinus carbonarius		
Eupachycrinus platybasis	cf.	Eupachycrinus cf. magister
Polypora sp.	cf.	Polypora magna
Fenestella sp.	cf.	Fenestella 3 sp.
Archimedes sp.	cf.	Archimedes juvenis
Discina sp.	cf.	Orbiculoidea missouriensis
Productus punctatus	=	Pustula punctata
longispinus?	cf.	Pustula sublineata
costatus?	cf.	Productus morrowensis
costatus var.		
prattenianus	=	Productus cora
semireticulatus		
nebraskensis	=	Pustula nebraskensis

muricatus		
multistriatus		
Chonetes granulifera	cf.	Chonetes choteauensis
platynota	cf.	laevis
Hemipronites crenistria	cf.	Orthotetes robusta
Meekella striatocostata	ibid.	
Spirigera subtilita	cf.	Composita ozarkana
Spirifer cameratus rockymontanus	ibid.	
Spiriferina octoplicata	cf.	Spiriferina transversa
Aviculopecten occidentalis	=	Deltopecten occidentalis
Myalina sp.	cf.	Myalina recurvirostris
Allorisma subcuneata		
Edmondia aspenwallensis	cf.	Edmondia subtruncata
Pleurophorus sp.	cf.	Pleurophorus tropidophorus
Schizodus wheeleri	cf.	Schizodus morrowensis
Bellerophon sp.	cf.	Bellerophon crassus var. wewokanus
Euomphalus sp.	cf.	Euomphalus catilloides
Pleurotomaria excelsa		
Naticopsis remex	cf.	Strophostylus subovatus?
Phillipsia sp.	cf.	Griffithides morrowensis

In Colorado the Molas formation, less than 80 feet in thickness, overlain by the Hermosa limestone, occurs at the base of the Pennsylvanian section in the San Juan region. The faunas of these formations have been described by Dr. Girty[33] and a comparison with the fauna of the Morrow makes it clear that they are probably somewhat younger than the Arkansas fauna. The fauna of the Molas is a very meager one and although every one of its eight species is represented in the Morrow fauna by either an identical or closely related form all of its fossils are species which occur at higher horizons in the Pennsylvanian and usually with greater abundance there than in the Morrow. Twenty of the Hermosa species have been identified in the Morrow but, again, they are long-range forms rather than those characteristic of the marine Pottsville. The absence of the residual Mississippian element from the Hermosa is as conspicuous as the absence from the Morrow of certain of the Hermosa forms, such as *Triticites secalicus*.

Toward the southwest from the Morrow outcrops there are known at several localities in Oklahoma and Texas limestones whose stratigraphic position is suggestive of a near relationship

to the Morrow. What little is known of the fauna of the Wapanucka limestone of southern Oklahoma and of the Marble Falls limestone in the Llano-Burnett region is in harmony with the idea that those formations may prove, when better known, to contain homotaxial equivalents of the Morrow.*

Ulrich has referred the Caney shale of the Ouachita region, Arkansas-Oklahoma, to the Pottsville and, as noted on page 65, has stated that a part of that formation is the equivalent of the Morrow. Woodworth[34] likewise places that formation in the Pottsville series. A comparison of the Caney fauna as described by Girty,[35] with the Morrow fauna as now known shows only one species, *Productus cora*, common to the two formations. It is evident that the fossiliferous portion, at least, of the Caney cannot be of Pottsville age.

In the attempt to find contemporaneous marine faunas in early Pennsylvanian strata outside of North America one's attention would naturally be directed toward eastern Europe with its great series of Carboniferous limestones. Among the known faunas from those terranes, that of the "Bergkalkschichten" of Mjatschkowa, as described by Trautschold,[36] presents the most striking similarities to the Morrow. Those beds are referred to the upper portion of the mountain limestone series and the fauna is doubtless typical of the "*Spirifer mosquensis* zone" of Russia. It would appear that its correlation with the Carboniferous succession of North America is with the Pottsville rather than the Chester stages.

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*Since the above was written I have received from Mr. C. R. Thomas, of the Oklahoma Geological Survey, a small collection of fossils from the Wapanucka limestone obtained at several localities in and near the Atoka and Coalgate quadrangles in south-central Oklahoma. Twenty-one species compose the fauna and all belong to genera found in the Morrow. Two are new species; eighteen are conspecific, or nearly so, with Morrow forms. The presence of *Pentremites angustus, Rhipidomella pecosi, Productus nanus, Spirifer opimus, Squamularia perplexa, Composita ozarkana, and Myalina orthonota* is conclusive evidence of the contemporaneity of the Wapanucka and Brentwood limestones.

Trautschold's faunal list, with suggested comparisons between it and the Morrow fauna, is as follows:

Mjatschkowa Fauna	*Morrow Fauna*
Endothyra radiata	no Foraminifera
Fusulina cylindrica Fisch.	
Nummulina antiquior Rouill.	
Nonionina rotula	
Bothrophyllum conicum (Fisch.)	cf. Campophyllum torquium
Clisiophyllum cavum Traut.	
Lithostrotion gorgoneum Traut.	
Hydnophora Humboldti Fisch. [not Hydnophora]	
Aulopora campanulata McCoy	cf. Aulopora sp.
Syringopora parallela Fisch.	no Syringoporidæ
Chaetetes tumidus (Phill.)	cf. Chaetetes milleporaceous
Chaetetes radians Fisch.	
Platycrinus sp. [identification doubtful]	
Forbesiocrinus incurvus Traut. [Synerocrinus incurvus (Traut.)]	no Flexibilia
Poteriocrinus multiplex Traut.	
Poteriocrinus bijugus Traut.	
Hydriocrinus pusillus Traut. [Pachylocrinus pusillus (Traut.)]	
Cromyocrinus simplex Traut.	
Cromyocrinus geminatus Traut.	
Cromyocrinus ornatus Traut.	cf. Cromyocrinus grandis
Phialocrinus patens Traut. [Graphiocrinus patens (Traut.)]	
Phialocrinus urna Traut. [Graphiocrinus urnus (Traut.)]	
Stemmatocrinus cernuus Traut.	
Paleaster montanus (Stschur.)	no Asteroidea
Stenaster confluens Traut.	
Calliaster mirus Traut.	
Archaeocidaris rossica (von Buch.)	cf. Archeocidaris sp.
Lepidesthes laevis Traut.	
Fenestella veneris (Fisch.)	cf. Fenestella 3 sp.
Polypora martis (Fisch.)	cf. Polypora 11 sp.
Polypora dendroides McCoy	
Ascopora rhombifera (Phill.) [Rhombopora nodosa (Fisch.)]	cf. Rhombopora 4 sp.
Ceriopora inaequabilis Traut. [not Ceriopora]	
Coscinium sellaeforme Traut.	cf. Coscinium 2 sp.

Coscinium Michelinia Prout	cf.	Glyptopora crassistoma
[Glyptopora michelinia (Prout)]		
Orthis resupinata (Martin)	cf.	Schizophoria resupinoides
[Schizophoria resupinata (Martin)]		
Orthis Lamarckii (Fisch.)		
[Enteletes lamarckii (Fisch.)]		
Orthis crenistria Phill.	cf.	Orthotetes robusta
[Orthotetes crenistria (Phill.)]		
Orthis senilis (Phill.)		
[Orthotetes, probably pedicle valves of O. crenistria.]		
Orthis eximia (Eichw.)	=?=	Meekella striatocostata
[Meekella eximia (Eichw.)]		
Chonetes variolata (d'Orb.)	cf.	Chonetes choteauensis
Productus cora d'Orb.	=	Productus cora
Productus undatus Defrance	cf.	Productus fayettevillensis
Productus semireticulatus (Martin)	cf.	Productus morrowensis
Productus longispinus Sowerby	cf.	Pustula sublineata
[Pustula longispina (Sowerby)]		
Productus punctatus (Martin)	=	Pustula punctata
[Pustula punctata (Martin)]		
Productus scabriculus (Martin)		
[Buxtonia scabricula (Martin)]		
Camarophoria crumena (Martin)	cf.	Pugnoides triangularis
Rhynchonella pleurodon Phill.	cf.	Rhynchopora magnicosta
Terebratula sacculus (Martin)	cf.	Dielasma bilobatum
[Dielasma sacculus (Martin)]		
Spirifer mosquensis (Fisch.)	cf.	Spirifer 3 sp.
Spirifer Strangwaysi Vern.		
Spirifer tegulatus Traut.		
Spirifer lineatus (Martin)	=?=	Squamularia perplexa
[Squamularia lineata (Martin)]		
Spirigera ambigua (Sowerby)	cf.	Composita ozarkana
[Composita ambigua (Sowerby)]		
Allorisma regulare King		
Sanguinolites undatus Portl.		
Sanguinolites tetraedrus Traut.		
Arco Argo Traut.	cf.	Parallelodon 2 sp.
[probably Parallelodon]		
Conocardium uralicum Keys.		
Anatina attenuata McCoy	cf.	Schizodus morrowensis
Anatina deltoidea McCoy		
Pecten ellipticus Phill.	cf.	Aviculopecten 6 sp.
Pecten plicatus Sowerby	cf.	Deltopecten occidentalis
Avicula evanescens Traut.		
Dentalium ornatum deKon.	no	Scaphopoda

Bellerophon Keymanus deKon.	
Bellerophon Urei Flemm.	cf. Bellerophon crassus var. wewokanus
Bellerophon costatus Sowerby	
Bellerophon decussatus Flemm.	
Pleurotomaria granulosa deKon.?	cf. Euconospira arkansana
Pleurotomaria Ivanii (Leveille)?	
Murchisonia angulata (Phill.)	cf. Worthenia tabulata
Euomphalus pentangulatus Sowerby	cf. Straparollus cf. spergenensis
Euomphalus tabulatus (Phill.)	cf. Euomphalus catilloides
Capulus pumilis Traut.	cf. Strophostylus subovatus
Capulus mitraeformis Traut.	cf. Platyceras parvum
Capulus parasiticus Traut.	
Macrochilus ampullaceus Fisch.	
Chemnitzia longispira Traut.	cf. Aclisina? sp.
Nerita ampliata (Phill.)	
Natica Omaliana deKon.	cf. Sphaerodoma sp.
Orthoceras ovale Phill.	
Orthoceras Polyphemus Fisch.	cf. Orthoceras sp.
Nautilus clitellarius Sowerby	cf. Gastrioceras 3 sp.
Nautilus subsulcatus Phill.	
Nautilus excentricus Eichw.	
Nautilus oxystomus Phill.	
Phillipsia pustulata Schloth.	cf. Griffithides 2 sp.
Phillipsia Grunewaldti Moller	

In addition to the points of similarity and difference suggested above, the absence from the Mjatschkowa fauna of *Zaphrentidae, Favositidae, Pentremites,* and *Archimedes* is noteworthy. *Archimedes,* however, is known to occur in the overlying Schwagerina limestone. The association in the Russian fauna of forms closely akin to representatives of both the residual Mississippian and proemial Pennsylvanian elements in the Morrow is readily apparent from the above lists. The presence of *Enteletes, Squamularia,* and *Meekella* is especially significant as indicative of Pottsville rather than Chester age. Although the parallelism between the two faunas is sufficiently close to suggest their contemporaneity the differences are sufficiently noteworthy to indicate that their development occurred in somewhat isolated provinces.

On the Brögger Peninsula in Spitzbergen, latitude 79° N, longitude 12° E, occurs a series of limestones with a fossiliferous horizon near its base, from which was obtained a fauna described

by Holtedahl.[37] Its resemblance to the Mjatschkowa fauna indicates a contemporaneous development in the same faunal province. It is apparent from the association of forms as listed below that in the light of the Morrow fauna the Moskauer stufe should be correlated with the Pottsville of North America.

Fauna der Moskauer Stufe des Spitzbergens

Cladochonus bacillaris McCoy
Syringopora parallela Fischer
Michelinia tenuisepta Phillips
Chaetetes radians Fischer
Platycrinus spitzbergensis Holtedahl
Fenestella elegantissima Eichwald
Fenestella sp.
    [very close to F. venusta]
Pinnatopora tenuis Eichwald
Ascopora nodosa (Fischer)
    [Rhombopora nodosa (Fischer)]
Coscinium sellaeforme Trautschold
Dielasma sacculus (Martin)
Dielasma sp. a.
Dielasma sp. b.
Eumetria vera Hall?
Camarophoria purdoni Davidson
Camarophoria pentameroides Tschernyschew
Spiriferina insculpta Phillips
    [very close to S. campestris]
Spiriferina holzapfeli Tschernychew
Spirifer fasciger Keyserling
    [cf. S. goreii]
Spirifer mosquensis Fischer
Reticularia lineata (Martin)
    [Squamularia lineata (Martin)]
Streptorhynchus pelargonatus Schlotheim
    [Orthotetes?]
Meekella eximia (Eichwald)
Rhipidomella michelini (Leveille)
Orthis (Rhipidomella?) sp.
Schizophoria indica Waagen
Schizophoria cf. juresanensis Tschernyschew
Orthotichia morgani (Derby)
Productus boliviensis d'Orbigny
Productus longispinus Sowerby
    [Pustula longispina (Sowerby)]
Productus cf. wallacei Derby

Productus isachseni Holtedahl
  [cf. P. gallatinensis]
Productus pustulatus Keyserling
  [Pustula pustulata (Keyserling)]
Productus irginae Stuckenberg
Productus cora d'Orbigny?
Productus punctatus (Martin)
  [Pustula punctata (Martin)]
Productus elegans McCoy
  [Pustula elegans (McCoy)]
Productus cf. fasciatus Kutorga
  [Pustula cf. fasciatus (Kutorga)]
Marginifera typica Waagen
Platyceras parvum Swallow
Phillipsia cf. eichwaldi Fischer
Griffithides ? cf. carringtonensis Etheridge
Petalodus sp.

One other locality is known which gives a clue toward obtaining knowledge of marine faunas contemporary with the Morrow. The Pendleside Group, a series of shales and limestones with occasional sandstones and mudstones, occupies a basin extending across central England, terminating toward the east near Chokier in Belgium and toward the west in County Clare, West Ireland. Its stratigraphical relations are singularly parallel to those of the Morrow as it rests apparently unconformably upon the Yoredale series and beneath the Millstone Grits. Its fauna has been listed by Hind and Howe[38] and contains the following invertebrates, compared with certain of the Morrow forms.

Pendleside Fauna		*Morrow Fauna*
Athyris ambigua	cf.	Composita 7 sp.
Chonetes Laguessiana	cf.	Chonetes 3 sp.
Discina nitida	cf.	Orbiculoidea 2 sp.
Lingula scotica		
Orthis michelini	cf.	Rhipidomella 2 sp.
Orthis resupinata	cf.	Schizophoria resupinoides
Productus cora		ibid.
Productus longispinus	cf.	Pustula sublineata
Productus punctatus	=	Pustula punctata
Productus scabriculus	cf.	Pustula nebraskensis
Productus semireticulatus	cf.	Productus morrowensis
Rhynchonella trilatera	cf.	Pugnoides triangularis
Spirifer glabra		
Streptorhynchus crenistria	cf.	Orthotetes robusta
Pteronites persulcata		

Pterinopecten papyraceus	
Leiopteria longirostris	
Posidonomya 2 sp.	
Chaenocardiola Footii	
Ctenodonta laevirostris	
Myalina 4 sp.	cf. Myalina 3 sp.
Nucula 2 sp.	cf. Nucula 2 sp.
Nuculana stilla	cf. Leda bellistriata
Posidoniella 3 sp.	
Sanguinolites tricostatus	cf. Sphenotus halensis
Schizodus antiquus	cf. Schizodus morrowensis
Solenomya costellatus	cf. Solenomya sp.
Parallelodon semicostatus	cf. Parallelodon 3 sp.
Pseudomusium fibrillosum	
Macrocheilina 3 sp.	
Dimorphoceras 3 sp.	
Epphipioceras clitellarium	
Gastrioceras 2 sp.	cf. Gastrioceras 3 sp.
Glyphioceras 11 sp.	
Nomismoceras spirorbis	
Orthoceras 5 sp.	cf. Orthoceras sp.
Coelonautilus quadratus	
Prolecanites 2 sp.	
Temnocheilus 2 sp.	
Bellerophon Urei	cf. Bellerophon 2 sp.

As thus listed, the differences between the two faunas appear about as significant as the likenesses. The Pendleside is largely a molluscan fauna while the molluscs are numerically inferior in the Morrow. Moreover, the residual element of the latter is not represented by comparable forms in the Pendleside fauna. If the faunas are contemporaneous they must have developed either in isolated basins or under very different environmental conditions.

DESCRIPTIONS OF SPECIES

COELENTERATA

ZAPHRENTIDÆ

Genus ZAPHRENTIS Rafenesque

Zaphrentis gibsoni White

Plate I, figures 1-2.

1884. *Zaphrentis Gibsoni.* White, 13th Rep. Geol. Surv. Ind., p. 117, pl. 23, figs. 4-5.

Coal Measures: Vermilion County, Indiana.

1903. *Zaphrentis gibsoni.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 323.
Middle and upper portion of Hermosa formation: San Juan region, Colorado.
Weber limestone: Crested Butte district, Colorado.

This species is represented by about a dozen specimens in none of which has the calyx been well preserved. Sections at several different stages of growth indicate the arrangement of septa which is characteristic of *Zaphrentis* as that genus is ordinarily interpreted. The major septa are divided into four quadrants by the conspicuous cardinal fossula bisected by the cardinal septum, the less conspicuous alar fossulae, and the scarcely perceptible counter fossula. There is a tendency for the major septa to fuse together at their inner ends. Externally the corals appear to resemble so closely the published figures and descriptions of *Zaphrentis gibsoni* that they are referred to that species with considerable confidence.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 135, and 152); Sawney Hollow, Oklahoma (Station 210). ?Kessler limestone: East Mountain, Fayetteville, Arkansas (?Station 209). Morrow formation: near Ft. Gibson, Oklahoma (Station 296).

Genus AMPLEXUS Sowerby

Amplexus corrugatus n. sp.

Plate I, figures 7-10.

Description. Corallum slender, conical in the lower portion and cylindrical in the mature stages of its growth, constricted at irregular intervals, many individuals geniculated, ordinarily gently curved, rarely straight, attaining a diameter of 6 or 7 mm. before a length of 20 mm. is reached, thereafter varying in diameter between 5 and 9 mm.; epitheca thin, longitudinally ribbed and concentrically striated, the striae more conspicuous immediately preceding the constrictions than elsewhere, bearing a few erect, hollow, tubular spines irregularly scattered over its surface but more numerous on the youthful conical portion of the corallum than on the mature cylindrical part; calyx not well displayed in any of the specimens at hand but probably deep.

In transverse sections the septa are seen to be about 22 or 24 in number in the mature regions and to extend slightly over

half way to the center. All are of approximately the same length and thickness and few are quite straight. In some sections the cardinal septum may be distinguished by a slightly greater length and by the fact that the other septa show a tendency to curve so that they are concave towards it. Dissepiments are rarely present in the peripheral portion.

In longitudinal section the tabulae are seen to be simple, flattened or very gently concave throughout the major part of their area, and abruptly curved downward close to their peripheries. They are usually about 1.5 mm. apart in the mature region.

Remarks. Only two species of *Amplexus* are known from the Pennsylvanian strata of North America, *A. zaphrentiformis* White and *A. sp.* Girty, both from the Cordilleran province. To the first, the species above described is evidently not closely related but with the second its affinities may be close.

Horizon and locality. Brentwood limestone: near Fayetteville (Station 134), and Brentwood (Station 145), Arkansas; Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Genus LOPHOPHYLLUM Milne-Edwards & Haime

Lophophyllum profundum (Milne-Edwards & Haime)

Plate I, figures 11-13.

1858. *Cyathaxonia profunda.* Milne-Edwards and Haime, Mon. des Polyp. Foss., p. 323.
Carboniferous: Flint Ridge, Ohio.

1860. *Cyathaxonia profunda.* Milne-Edwards, Hist. Nat. Corr., vol. 3, p. 331.
Carboniferous: Ohio.

1860. *Cyathaxonia prolifera.* McChesney, Desc. New Pal. Foss., p. 75.
Coal Measures: Widely distributed in the Western States.

1865. *Cyathaxonia prolifera.* McChesney, Ill. New Spec. Foss., pl. 2, figs. 1-3.

1866. *Cyathaxonia* (?) *sp.* Geinitz, Carb. und Dyas in Nebr., pp. 65, 66, tab. 5, figs. 3-4.
Plattsmouth, Nebraska.

1868. *Cyathaxonia prolifera.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 1, pl. 2, figs. 1-3.
Coal Measures: Springfield, Illinois.

1872. *Lophophyllum proliferum.* Meek, U. S. Geol. Surv. Nebr., p. 149, pl. 5, figs. 4 a-b.
Upper Coal Measures: Nebraska City and Rock Bluff, Nebraska; Springfield and LaSalle, Illinois; Texas.

1873. *Lophophyllum proliferum.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 560, pl. 24, fig. 1.
Upper Coal Measures: Springfield, Illinois.

1876. *Lophophyllum proliferum.* White, Powell's Geol. Rep. Uinta Mts., p. 88.
Lower Aubrey Group: Confluence of Grand and Green rivers, Utah.

1884. *Lophophyllum proliferum.* White, 13th Rep. Geol. Surv. Ind., p. 118, pl. 23, figs. 6-7.
Coal Measures: Indiana; Illinois; Iowa.

1887. *Cyathaxonia prolifera.* Foerste, Bull. Sci. Lab. Den. Univ., vol. 2, p. 86, pl. 7, figs. 15a-c.
Coal Measures: Flint Ridge and Bald Hill, Ohio.

1888. *Lophophyllum profunda.* Foerste, Bull. Sci. Lab. Den. Univ., vol. 3, p. 136.
Coal Measures: Flint Ridge, Ohio.

1888. *Lophophyllum proliferum.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 225.
Lower Coal Measures: Des Moines, Iowa.

1890. *Lophophyllum profundum.* Worthen, Geol. Surv. Ill., vol. 8, p. 79, pl. 10, figs. 14-14a.
Coal Measures: LaSalle, Illinois.

1894. *Lophophyllum proliferum.* Keyes, Mo. Geol. Surv., vol. 4, p. 115, pl. 13, figs. 8a-b.
Upper Coal Measures: Kansas City, Missouri.

1897. *Lophophyllum proliferum.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 25.
Upper Coal Measures: Poteau Mountain, Indian Territory.

1900. *Lophophyllum profundum.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 17, pl. 2, figs. 7-7b.
Upper and Lower Coal Measures: Fort Scott, Marmaton, Bourbon County, Thayer, Olathe, Kansas City, Lawrence, Lecompton, Topeka, McFarland, and Grand Summit, Kansas.

1903. *Lophophyllum profundum.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 320.
Lower, Middle, and Upper portions of Hermosa formation: San Juan region; Dolores River region, Sinbad's Valley, Colorado.
Maroon formation: Crested Butte district, Colorado.
Grand River region, Glenwood Springs.
Uinta Mountain region, overlooking Tampa River.

1909. *Lophophyllum proliferum.* Brown, Ann. N. Y. Acad. Sci., vol. 19, p. 80, text figs. 1-11.

1910. *Lophophyllum profundum.* Raymond, Ann. Carnegie Mus., vol. 7, p. 157, pl. 25, fig. 2; pl. 27, fig. 4.
Ames limestone: Brilliant Cut-off, Pittsburg, Pennsylvania.

1911. *Lophophyllum profundum.* Raymond, Penn. Topog. and Geol. Surv. Comm., Rept. for 1908-10, pl. 6, fig. 1.
Ames limestone: Brilliant Cut-off, Pittsburg, Pennsylvania.

1913. *Lophophyllum profundum.* Mark, Geol. Surv. Ohio, 4th ser., Bull. No. 17, p. 300, pl. 13, fig. 1.
Conemaugh formation, Brush Creek, Ames, and Cambridge limestones; Portersville shale: Ohio.
Ames limestone: Deersville, Ohio.

1914. *Lophophyllum profundum.* Price, West Va. Geol. Surv., Preston County Rept., p. 488.
Brush Creek limestone: 0.9 mile west and 0.9 mile northeast of Bruceton Mills, West Va.

This species is represented by a number of specimens, many of which are in good condition. Externally the appearance is that typical of the species as identified from numerous Pennsylvanian localities. Internally the septal development is the same as that described by Brown; a series of sections made from one individual displays the successive stages in growth observed by that author.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

CYATHOPHYLLIDÆ

Genus CAMPOPHYLLUM Milne-Edwards & Haime

Campophyllum torquium (Owen)

Plate I, figures 14, 14a.

1852. *Cyathophyllum (vermiculare?).* Owen, Geol. Rep. Wis., Iowa and Minn., tab. 4, fig. 2.
Carboniferous limestone: Near mouth of Keg Creek.

1852. *Cyathophyllum torquium.* Owen, Geol. Rep. Wis., Iowa and Minn., tab. 4, fig. 2.
Carboniferous limestone: Near mouth of Keg Creek.

1852. *Cyathophyllum flexuosum (?).* Owen, Geol. Rep. Wis., Iowa and Minn., tab. 4, figs. 3a-b.
Carboniferous limestone: Near mouth of Keg Creek.

1872. *Campophyllum torquium.* Meek, U. S. Geol. Surv. Nebr., p. 145, pl. 1, figs. 1a-d.
Upper Coal Measures: Rock Bluff and Cedar Bluff, Nebraska; Iowa.
Coal Measures: Illinois.

1884. *Campophyllum torquium.* White, 13th Rep. Geol. Surv. Ind., p. 119, pl. 23, figs. 10-13.
Upper Coal Measures: Iowa; Missouri; Nebraska; Illinois; Indiana.

1894. *Campophyllum torquium.* Keyes, Mo. Geol. Surv., vol. 4, p. 107, pl. 12, figs. 7a-c; pl. 13, fig. 7.
Coal Measures: Kansas City, Missouri.

1898. *Campophyllum torquium.* Beede, Kans. Univ. Quart., vol. 7, p. 187-188, text figs. 1-4, p. 190.
Coal Measures: Jefferson, Douglas, and Chautauqua Counties, Kansas; Northrop's Woods, about 3 miles west of Kansas City, Missouri.

1900. *Campophyllum torquium.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 19, pl. 4, fig. 1; pl. 5, figs. 1-4.
Coal Measures: Kansas City, Jefferson, Douglas, and Chautauqua Counties, Kansas.

1903. *Campophyllum torquium.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 323.
Upper portion of Hermosa formation: San Juan region; Ouray, Colorado.
Weber limestone and Maroon conglomerate: Crested Butte district, Colorado.

The half-dozen specimens subsumed here present no important differences from the Pennsylvanian forms frequently referred to this species. Only one corallum displays the mature development; the others are comparatively small and have attained little growth beyond the conical stage.

Horizon and locality. Brentwood limestone: near Brentwood, Arkansas (Stations 145 and 147); Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

FAVOSITIDÆ

Genus PACHYPORA Lindström

Pachypora carbonaria n. sp.

Plate I, figures 15-16.

Description. Corallum large, 35 to 85 mm. in its major diameter, irregular in form, sub-cylindrical, sub-ovoid or ramose, corallites opening in all directions; corallites polygonal in cross-section, bounded by walls which are quite thin in the axial portion and become greatly thickened adjacent to the surface of the corallum, variable in size, but commonly with a diameter between 2.0 and 3.5 mm.; calyces with depth greater than diameter, sub-circular in cross-section, somewhat funnel-shaped, and bounded by thick walls; septa not apparent in the material at hand; tabulae thin, numerous in the axial region where 5 or 6 occur in the space of a diameter, convex upward, and in many instances arching diagonally from the corallite wall to

the central portion of the preceding tabula; mural pores only rarely present, irregularly placed.

Remarks. The genus *Pachypora* has not heretofore been reported from the Carboniferous strata of North America although it is known in the Productus limestone of the Salt Range and possibly elsewhere in Europe and Asia. The thickening of the walls of the calyces, the close spacing of the tabulae, and the irregular distribution of the mural pores, as displayed by the specimens at hand, point unmistakably to the reference of the species to this genus. The corallum is ordinarily much larger and the corallites have a much greater diameter in *P. carbonaria* than in either of the Salt Range forms.

Horizon and locality. Brentwood limestone: near Brentwood, Arkansas (Station 145). Morrow formation: near Ft. Gibson (Stations 296 and 301), and Choteau (Station 297), Oklahoma.

Genus MICHELINIA De Koninck

Michelinia eugeneae White

Plate I, figures 17, 17a; Plate II, figure 1.

1884. *Michelinia eugeneae.* White, 13th Rep. Geol. Surv. Ind., p. 119, pl. 23, figs. 14-16.
Coal Measures: Edwardsport, Knox County, and Eugene, Vermilion County, Indiana.

1894. *Michelinia branneri.* Miller and Gurley, Bull. No. 3, Ill. State Mus. Nat. Hist., p. 68, pl. 7, figs. 12-13.
Coal Measures: Danville, Illinois.

1900. *Michelinia eugeneae.* Beede, Univ. Geo. Surv. Kas., vol. 6, p. 21, pl. 2, figs. 12-12b.
Upper Coal Measures: Pomeroy, Wyandotte County, Kansas.

Description. Corallum variable in size and shape, but generally globular or irregularly ovoid in form with height either greater or less than major transverse diameter, the greatest diameter in few specimens less than 20 mm. and not known to exceed 85 mm.; corallites opening upon all sides except the base which is covered with a wrinkled, concentrically striated epitheca extending for a variable but small distance from the point of attachment; the corallites polygonal, commonly hexagonal or pentagonal in cross-section, and with quite diverse diameters, the majority of which fall between 2 and 3 mm.; calyces exceeding in depth the diameter of the corallites and bounded by thin walls; septa represented by numerous longi-

tudinal striations on the inner walls of the calyx but not easily discernible in cross-sections; tabulae numerous, very thin, irregularly spaced, more commonly convex upward but in some instances plane or concave, not all completely crossing the corallite from wall to wall, but some arching from the central portion of the preceding tabula to the wall of the corallite; mural pores with a diameter about one-third as great as the width of the walls, not numerous, irregularly scattered.

Remarks. There can be no doubt, so far as a study of descriptions and figures indicates, that the forms thus described are conspecific with those to which this name was first given by White. The arrangement of tabulae and mural pores makes quite clear the correctness of the generic reference.

Horizon and locality. Brentwood limestone: near Fayetteville (Stations 135, 147, and 152), and Brentwood (Station 145), Arkansas; Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood, Arkansas (Station 144). Morrow formation: near Ft. Gibson (Stations 296 and 301), Choteau (Stations 298 and 302), Hulbert (Station 299), and Gore (Station 305), Oklahoma.

Michelinia exilimura n. sp.

Plate II, figures 2, 2a.

Description. Corallum a large, irregularly expanding lenticular mass which may attain a diameter of at least 125 mm.; corallites polygonal, many of them hexagonal or pentagonal in cross-section, variable in size, but commonly with a diameter between 3 and 6 mm.; calyces, basal attachment, and epitheca not preserved in either of the two specimens at hand; as displayed in sections the corallite walls are very thin, scarcely half as thick as those of *M. eugeneae,* the tabulae are very numerous, from 5 to 7 occurring in the space of one diameter in the axial region, quite variable in curvature with probably a slight preponderance of those which are convex upward, nearly as thick as the inter-corallite walls and in many cases directed at acute angles with the walls, thus intersecting each other at diverse angles; mural pores are small, irregularly distributed, and not very abundant.

Remarks. In comparison with *M. eugeneae*, the larger size of corallites and corallum, as well as the approach toward equality in the thickness of walls and tabulae which characterizes this species, is noteworthy. *M. meekana* Girty from the Chester horizon in the Boston Mountain region is comparable to it in size but is probably a different species as it is said to have "moderately thick" walls.

Horizon and locality. Morrow formation: near Choteau, Oklahoma (Stations 297 and 307).

Michelinia subcylindrica n. sp.

Plate I, figure 18.

Description. Corallum small, irregularly sub-cylindrical in form, with the height commonly much greater than any transverse diameter, cross-section more or less circular, the largest specimen 15 mm. in height, the average less than 7 or 8 mm.; the base small and conical, covered with a wrinkled, concentrically striated epitheca which does not extend far upon the sides of the colony in any of the specimens at hand; corallites small, opening upon all sides of the corallum except at the base, polygonal, many of them hexagonal or pentagonal, in cross-section with slightly rounded angles, their diameter variable but the majority with a diameter between 0.5 and 1.0 mm.; calyces generally exceeding in depth the diameter of the corallite, bounded by thin walls which are ordinarily slightly thicker at the intersecting angles than elsewhere; septa, tabulae, and mural pores as in *M. eugeneae*.

Remarks. The small size of the corallites and the size and shape of the corallum serve to distinguish this form readily from the more common *M. eugeneae*. In a sense, the mode of growth of the corallum is intermediate between that of White's species and the form described by Ulrich from the Ste. Genevieve as *M. subramosa*. In comparison with the latter its corallites are, again, conspicuously smaller.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

AULOPORIDÆ

Genus AULOPORA Goldfuss

Aulopora sp.

Plate I, figure 6.

A single specimen of a small trumpet-shaped coral attached throughout its entire length to a fragment of a *Cystodictya* and reproducing by basal gemmation, is believed to represent the genus *Aulopora.* Its specific relations are not apparent and it is probably an undescribed form. About three corallites occupy the space of 5 mm. longitudinally; the average diameter of the calyx is 0.4 mm.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Genus CLADOCHONUS M'Coy

Cladochonus fragilis n. sp.

Plate I, figures 3-5.

Description. Corallum branching; the delicate, funnel-shaped or cylindrical corallites increasing by lateral gemmation, attached only at the base or occasionally throughout the colony. Corallites without tabulae or septa, the latter represented by faint rounded striae on the interior wall of the corallite. Epitheca faintly wrinkled or smooth; upper portion of the wall of the calyx thin, but thickening interiorly downward; calyx circular. Individual corallites generally expand symmetrically upward from the base, until the point of gemmation is reached; there a single bud is given off and immediately beyond the base of the new individual the older one curves sharply away and flares out rapidly toward the margin of the calyx, giving an approximation to a trumpet shape to the more sharply curved individuals. The point of gemmation is located on the average about four-fifths the distance from base to calyx opening. Average diameter of calyx: 1.5 mm.; average length of individual: 3 mm.

Remarks. The material at hand consists of fragments of a broken colony, or colonies, none of which show any attachment to foreign objects. The species resembles neither of the two described American species of *Cladochonus,* being much smaller

than C. *americanus* Weller and lacking the strongly wrinkled epitheca of *C. bennetti* Beede.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

CHAETETIDÆ

Genus CHAETETES Fischer

Chaetetes milleporaceous Milne-Edwards & Haime

1851. *Chaetetes milleporaceous.* Milne-Edwards and Haime, Mon. des Polyp. Foss., p. 272.
Carboniferous: Cumberland Mountains, Tennessee; Newburg, near Evansville on the Ohio.

1860. *Chaetetes milleporaceous.* Milne-Edwards and Haime, Hist. Nat. des Corr., vol. 3, p. 271.
Carboniferous: United States.

1876. *Chaetetes milleporaceous.* White, Powell's Geol. Rep. Uinta Mts., p. 88.
Red Wall Group: Gypsum Canyon, Colorado River, Utah.
Lower Aubrey Group: Split Mountain Canyon, Green River, Utah.

1877. *Chaetetes millepraceous.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 98, pl. 6, fig. 2a.
Carboniferous: Virgin Range, southwest of St. George, Utah.

1894. *Chaetetes milleporaceous.* Keyes, Mo. Geol. Surv., vol. 4, p. 123, pl. 14, figs. 12a-b.
Upper Coal Measures: Glasgo, Missouri.

1900. *Chaetetes milleporaceous.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 25, pl. 2, figs. 11-11b.
Coal Measures: Girard, Kansas; very abundant in the Oswego limestone.

1903. *Chaetetes milleporaceous.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 328.
Middle portion of Hermosa formations: San Juan region, Colorado.
Maroon conglomerate: Crested Butte district, Colorado.

1904. *Chaetetes milleporaceous.* Girty, Prof. Paper, U. S. Geol. Surv., No. 21, p. 52, pl. 11, fig. 2.
Virgin Range, southwest of St. George, Utah.
Naco limestone: Bisbee quadrangle, Arizona.

Only one specimen of this species is present in the Morrow collections. It is an irregular mass, 30 by 40 by 50 mm. in size, apparently incomplete on all surfaces. The corallites are polygonal in cross-section, very commonly with one diameter longer than the others, and in most cases attain a diameter of 0.3 or 0.4 mm. In longitudinal section the tabulae appear to be situated quite regularly about one diameter apart or a little less

and are flat and parallel to each other. The material at hand does not, therefore, differ in any important particular from the typical form of the species.

Horizon and locality. Morrow formation: near Choteau, Oklahoma (Station 298).

BLASTOIDEA

PENTREMITIDÆ

Genus PENTREMITES Say

Pentremites angustus Hambach

Plate III, figures 10-13a.

1903. *Pentremites angustus.* Hambach, Trans. Acad. Sci. St. Louis, vol. 13, p. 53, text figs. 14a-b.

Chester limestone: Washington County, Arkansas.

Description. Body conical, more or less elongate and obtuse, the length of the ambulacral plates nearly as great as the height of the body; base very moderately convex or flattened, basal plates small and not discernible in a lateral view in the specimens with a more flattened base; ambulacral plates about 5 times as long as wide, ambulacral pores about 17 in 5 mm.; deltoid plates nearly or quite twice as long as wide; interambulacral spaces flat or moderately concave, the surface of the plates finely striated parallel to their margins, the striations apparent only when the preservation is perfect.

Dimensions of Three Individuals.

Height	22.7 mm.,	21.0 mm.,	19.0 mm.
Maximum diameter	16.5 mm.,	18.4 mm.,	15.3 mm.
Length of ambulacral plates	21.0 mm.,	19.5 mm.,	17.5 mm.
Maximum width of ambulacral plates	3.9 mm.,	4.0 mm.,	3.7 mm.
Length of deltoid plates	9.4 mm.,	9.3 mm.,	8.6 mm.
Maximum width of deltoid plates	5.1 mm.,	5.1 mm.,	4.3 mm.
Length of basal plates, from center of basal attachment scar	4.5 mm.,	6.1 mm.,	4.2 mm.
Average number of side plates in 5 mm	17	17	17

Remarks. Hambach's material was doubtless obtained from one of the limestone horizons of the Morrow group as the "Pentremital limestone" [=Brentwood limestone] of Washington County was believed by the Arkansas Survey to be of Chester age.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136 and 137). Brentwood limestone: near Fayetteville (Stations 134, 135, 140, 147, 152, and 153), and Brentwood (Station 145), Arkansas. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Pentremites rusticus Hambach

Plate III, figures 3-6a.

1903. *Pentremites rusticus.* Hambach, Trans. Acad. Sci. St. Louis, vol. 13, p. 54, text fig. 15.
Chester limestone: Washington County, Arkansas.

Description. Body sub-cylindrical, diameter and height subequal, diameter near upper extremity nearly as great as that near base, the greatest diameter occurring near the mid-height of the body; ambulacral plates nearly as long as the height of the body, the base flattened or moderately concave, the basal plates small; length of ambulacral plates 3½ or 4 times their width, ambulacral pores about 17 in 5 mm.; deltoid plates comparatively small, their width about two-thirds their length in adults; inter-ambulacral spaces flat or moderately concave, strongly elevated above the ambulacrals, the elevation being at a maximum at the apex of the deltoids and decreasing toward the base of the body; the margins of the plates bordering the ambulacral notches abruptly and strongly thickened, surface of plates finely striated parallel to their margins.

DIMENSIONS OF THREE INDIVIDUALS.

Height	17.9 mm.,	17.3 mm.,	9.9 mm.
Maximum diameter	18.0 mm.,	17.0 mm.,	9.5 mm.
Length of ambulacral plates	17.7 mm.,	16.3 mm.,	9.0 mm.
Maximum width of ambulacral plates	4.7 mm.,	4.8 mm.,	3.5 mm.
Length of deltoid plates	6.3 mm.,	4.7 mm.,	2.7 mm.
Maximum width of deltoid plates	3.5 mm.,	3.0 mm.,	1.0 mm.
Length of basal plates, from center of basal attachment scar	4.5 mm.,	4.4 mm.,	1.7 mm.
Average number of side plates in 5 mm	17	17	17

Remarks. In comparison with *P. angustus*, this species is characterized by its barrel-shaped, rather than conical, body, the strong elevation of the interambulacral plates, the comparatively small deltoids and broad ambulacrals, and the equality between height and diameter. The two species, although both

quite abundant, have been found associated at only one locality, Station 301. With the exception of that occurrence, *P. angustus* is not represented in any of the Oklahoma collections while in the material upon which these studies are based *P. rusticus* has not been observed in any of the collections from Arkansas. Hambach, however, described both species as occurring in Washington County, Arkansas. Probably the fact is that *P. angustus* was rare in the western part and *P. rusticus* was rare in the eastern part of the Morrow basin. Hambach's reference to the "Chester limestone" is, of course, to the limestone of the Morrow group.

Horizon and locality. Brentwood limestone: Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Choteau (Stations 307 and ?298), Ft. Gibson (Station 301), and Gore (Station 305), Oklahoma.

CRINOIDEA

POTERIOCRINIDÆ

Genus HYDREIONOCRINUS De Koninck

Hydreionocrinus sp.

Plate II, figures 5-6a.

A number of the spatulate spinous plates which surround the summit of the ventral sac of the crinoids referred to this genus are in the Morrow collections. Nothing is known as to the other parts of these forms and therefore their specific relationships cannot be suggested.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 147 and 152). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Genus CROMYOCRINUS Trautschold

Cromyocrinus grandis n. sp.

Plate III, figures 2, 2a; text figure 1.

Description. Dorsal cup large and globose, its height equal to about five-eighths its diameter, base convex, the column attachment a crater-like depression surrounded by an elevated ridge, the upper portion of the cup constricted with the greatest diameter occurring at about the middle of its height; infrabasals

five, closely united by scarcely discernible sutures into a large convex pentagonal plate; the posterior and right posterio-lateral basals hexagonal, the others pentagonal, each nearly as large as the combined infrabasal plates and extending outward and upward beyond the plane of greatest diameter of the cup, thus including its most convex portion; radials pentagonal, their height about three-fifths their width, very gently convex longitudinally and transversely, their upper faces truncated throughout the entire width and length for the articulation of the primibrachs, the articulating facet occupying the middle two-thirds of their length; radianal large, pentagonal, resting upon the

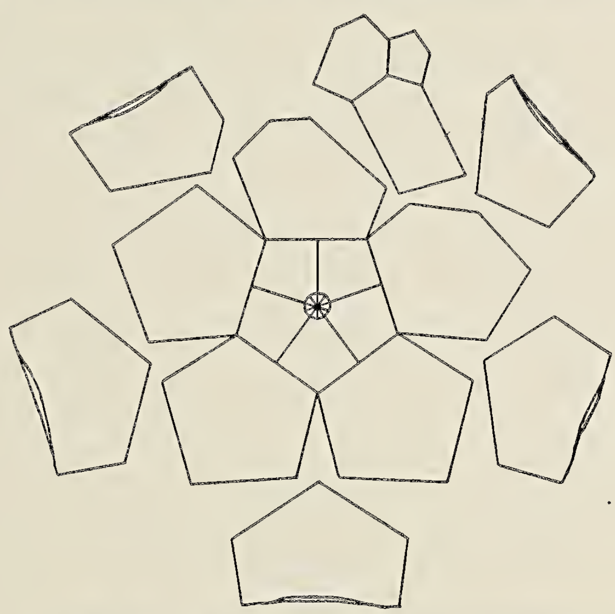

Fig. 1. Diagram of *dorsal cup of Cromyocrinus grandis.*

truncated upper angles of the posterior and right posteriolateral basals beneath the right posterior radial, supporting upon its truncated upper faces the inter-radianal and anal plates; inter-radianal hexagonal, smaller than the radianal, resting upon the truncated upper angles of the posterior basal and the radianal, between the left posterior radial and the anal plate; anal small, pentagonal, resting upon the truncated edge of the radianal and situated in part between the inter-radianal and the left posterior radial, its upper third projecting beyond the margin of the radials; arms and ventral disk unknown.

The dimensions of the holotype are: diameter of dorsal cup, 56 mm.; height of dorsal cup, 37 mm.; diameter at upper faces of the radials, 43 mm.

Remarks. The genera *Cromyocrinus* and *Eupachycrinus* are so closely related that they have sometimes been thought to be equivalent. The distinguishing characteristics are the small size of the infrabasal plates, which are commonly concealed by the column and are situated in a funnel-shaped cavity, of the latter genus in contrast to the larger infrabasals and convex or flattened base of *Cromyocrinus.* As thus distinguished *Cromyocrinus* is represented by only three previously described American species. These are *C. globosus, C. hemisphericus,* and *C. papillatus,* all described by Worthen from the Chester of Illinois. The type of the genus is *C. simplex* Trautschold from the *Spirifer mosquensis* zone of the Russian Carboniferous. The crinoid from the Coal Measures of Illinois described by Meek and Worthen as *Cyathocrinus? sangamonensis* has been referred[39] to *Cromyocrinus,* but its true generic position is with *Ulocrinus* as it has only two azygous plates, the smaller one of which, the anal, rises partly above the level of the radials. *Cromyocrinus* therefore appears to be restricted, as far as it is known in North America, to the Chester and Pottsville stages of mid-Carboniferous times. Another undescribed species of the genus, much smaller than that now under discussion, has been recognized in a collection of fossils from the Wapanucka limestone which has recently come to hand.

In comparison with other members of the genus *C. grandis* is distinguished primarily by its large size, none of the other species attaining much over one-half as great a diameter. The crater-like projection for the attachment of the stem, the marked constriction of the upper portion of the radials, and the close union of the infrabasal plates are also worthy of note.

Horizon and locality. Brentwood limestone: near Brentwood, Arkansas (Station 145).

Genus EUPACHYCRINUS Meek & Worthen

Eupachycrinus cf. **magister** Miller & Gurley

Plate II, figures 7-9.

Numerous isolated basal and radial plates in several of the Morrow collections represent an *Eupachycrinus* which seems to closely resemble *E. magister.* The plates are covered with closely spaced, rounding tubercles irregularly scattered over the

surface, as indicated in the figures of this species represented by Beede on plate VI of vol. VI, Univ. Geol. Surv. of Kansas, which they resemble more closely than they do the figures of the type specimen.[40]

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 152); Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Genus DELOCRINUS Miller & Gurley

Delocrinus dubius n. sp.

Plate III, figures 7-7b; text figure 2.

Description. Dorsal cup below medium size, depressed bowl-shaped, base deeply concave, upper margin constricted, greatest

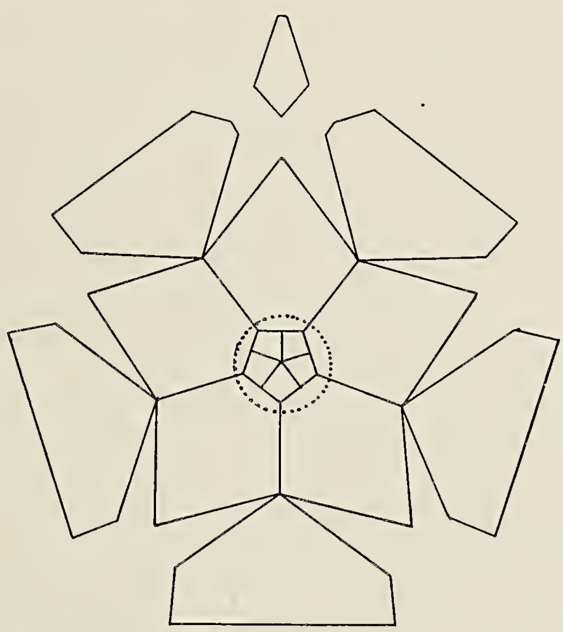

Fig. 2. Diagram of *dorsal cup of Delocrinus dubius.*

diameter about midway of the height; infrabasals situated at the bottom of the deep funnel formed by the concavity of the base, concealed by the column; basals five, pentagonal, the posterior basal longer than the others but not truncated above for the attachment of the anal plate, the lateral and anterior basals with length slightly greater than width, all strongly and regularly convex longitudinally and moderately concave transversely; radials comparatively thick and massive, the two posterior ones hexagonal, the other three pentagonal in form, strongly convex

longitudinally, moderately convex transversely, nearly twice as wide as high, truncated and faceted above for the attachment of the primibrachs; anal plate small, pentagonal, nearly three times as long as wide, resting upon the truncated angles of the two posterior radials and situated in the main above the radials, only the lower one-fourth of its length being within the dorsal cup, its surface sloping strongly toward the center of the ventral sac, and reclining at an angle of about 45° with respect to the axis of the calyx; arms and ventral sac unknown.

The dimensions of the individual selected as the holotype are: outside diameter of dorsal cup, 15.8 mm.; diameter of periphery of upper margin of dorsal cup, 13.4 mm.; diameter of body cavity, 7.4 mm.; height of dorsal cup, 5.5 mm.

Remarks. The generic relationships of this crinoid, the most abundant one in the Morrow collections, are not altogether clear. In general form and because of the deep funnel-like concavity of its base, its affinities seem to lie with the members of the genus to which it has been referred, but the position of the anal plate which misses contact with the posterior basal by about 0.3 mm. is unlike that of the species referred with certainty to *Delocrinus* by Miller and Gurley[41]. In the latter forms the posterior basal is truncated for the attachment of the anal plate which is situated between the posterior radials. The relationship of *D. dubius* to *Erisocrinus? planus* White, the generic position of which is also in doubt, is probably very close.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 135, and 153). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Delocrinus pentanodus n. sp.

Plate III, figures 8-8b; text figure 3.

Description. Dorsal cup small, low, basin-shaped, with slightly concave base and no constriction at upper margin of radials; infrabasals five, suture lines scarcely discernible, projecting well beyond the shallow circular depression of the stem attachment; basals five, pentagonal in outline, the posterior basal hexagonal because of truncation for the anal plate, gently convex transversely and longitudinally throughout the greater part of each plate but abruptly deflected upward near the acute outer

angle, each plate bearing a single, massive, sub-centrally situated, horn-shaped node protruding outward and curving laterally from just within the flattened basal portion of the cup; radials pentagonal, broader than high, comparatively thick and massive, strongly convex longitudinally, more gently convex laterally, central portion thickened and tumid, upper surface truncated and faceted for attachment of primibrachs; anal plate small, quadrilateral, resting upon the truncated edge of the posterior basal between the posterior radials; body cavity shallow, cylindrical; arms and ventral disc unknown.

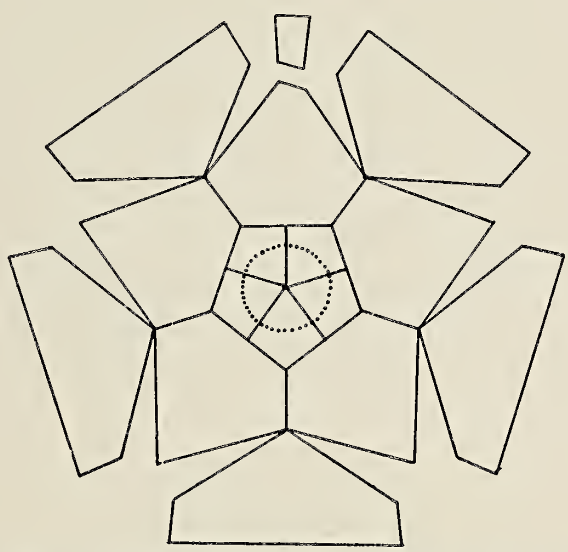

Fig. 3. Diagram of *dorsal cup of Delocrinus pentanodus.*

The dimensions of the holotype are: outside diameter of dorsal cup, 8.8 mm.; height of dorsal cup, 2.5 mm.; diameter of body cavity, 4.4 mm.; depth of body cavity, 1.7 mm.

Remarks. Only one other species of this genus, *D. noduliferous* (Butts), described from the Upper Coal Measures at Kansas City, Missouri, is characterized by the presence of nodes on the plates of the dorsal cup. From that species the one here described may be distinguished by the larger size of the infrabasals relative to the diameter of the stem, the pentagonal form of the radials, and the absence of nodes or spines on the radials.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Delocrinus sp.

Plate III, figures 1-1b.

A third species of *Delocrinus*, larger than either of the two described above, is represented by a portion of the dorsal cup consisting of three basal and two radial plates. The shape of the cup and the funnel-like concavity of the base are similar to those of *D. dubius*. The basals are pentagonal, longer than wide, strongly convex longitudinally and gently concave laterally; radials pentagonal, much wider than long, their surfaces sharply deflected along a line situated at the mid-length so that the upper portion of the plates is at approximately right angles to the lower portion; the anal side of the cup is missing. The surface of both basal and radial plates is coarsely pustulose and bears numerous, irregularly scattered, moderately large, tumid nodes, which are not present above the line of deflection of the radials; in addition there are indications that the basals, whose surface is deeply eroded in the material at hand, were ornamented by a single, large, sub-central spine or node. The specific relations of the specimen are not apparent.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Genus STEREOBRACHICRINUS n. gen.

Crinoids with inflexible uniserial arms, the plates of which are solidly united by firm sutures so that no motion of the arms above the attachment to the radials is possible. Ambulacral groove narrow, about as deep as wide; nerve canal situated near the center of the arm.

This genus is based upon a half dozen specimens consisting of more or less complete, isolated arms. The dorsal cup is unknown and the reference to the *Poteriocrinidae* is provisional. No evidence that the arms were pinnulate has been observed.

Genotype:

Stereobrachicrinus pustullosus n. sp.

Plate III, figures 9, 9a.

Description. Arms uniserial, inflexible, sub-trigonal to subcircular in cross-section, tapering gradually toward either end, very gently curved so that the ambulacral side is concave longi-

tudinally; length of arm about 25 or 30 mm., maximum diameter, near the mid-length, about 5 mm., diameter at either end about half that at the middle; plates composing the arms varying in height from 2 to 3 mm., end surfaces plane, united by close sutures, lateral surfaces bearing coarse granular pustules with the exception of the ambulacral surface which is smooth; ambulacral groove about 0.5 mm. in width and depth, cover-plates not discernible, nerve canal central; no indication of pinnules present. Dorsal cup unknown.

Remarks. In none of the specimens for which this species is erected is the articulating facet by which the arms were united to the radials preserved. Where broken the arms have fractured irregularly across the plates except in one specimen where the fracture follows the suture between two plates. The arms are evidently the most readily preserved portion of this crinoid and so far as known are unique in their structure.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Crinoid plates.

Plate II, figures 3-4a.

In addition to the isolated plates from a dorsal cup which have been described above as *Eupachycrinus cf. magister* there are in the Morrow collections a number of primibrachial plates which are of considerable interest. They may be roughly grouped into two classes, a larger bulbous variety illustrated in figures 3 and 3a of Plate II, and a smaller spinous type represented by figures 4 and 4a of the same plate. The former group includes two specimens, both from the Brentwood limestone (Stations 147 and 210), which may perhaps belong to the same species which furnished the isolated basal and radial plates found at the latter locality. The smaller, more spinelike variety is present in considerable numbers in the collections from the Morrow formation made at Stations 296 and 301. It is possibly to be referred to *Delocrinus dubius*.

ECHINOIDEA

ARCHAEOCIDARIDÆ

Genus ARCHAEOCIDARIS M'Coy

Archaeocidaris sp.

Plate II, figure 10.

The echinoidea are represented in the Morrow collections by three of the spines which are characteristic of members of this genus. The spines are slender, elongate, circular in cross-section, with an articulating facet at the lower end, and ornamented by exceedingly fine, closely spaced, longitudinal striations which are visible only with the aid of a hand lens. Their specific relations are not apparent.

A single, much-worn echinoid plate bearing an articulation facet for the attachment of a spine is present in the collection from Station 296. It presumably belongs to the same species as the spines.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 147). Morrow formation: near Ft. Gibson, Oklahoma (Station 296).

BRYOZOA

FISTULIPORIDÆ

Genus FISTULIPORA M'Coy

Fistulipora sp.

Plate IV, figures 1, 2.

The genus *Fistulipora* is represented in the Morrow collections by a number of fragmentary specimens whose specific relationships are not known with certainty. The zoaria are irregularly curved, laminar expansions composed of superimposed layers of zooecia and with a strongly wrinkled epitheca over the basal surfaces. The upper surfaces of the zoaria are marked by inconspicuous maculae of irregular shape and small size occurring at intervals of 4 or 5 mm. The apertures display various outlines depending upon the degree of preservation of the lunarium which when little worn is prominent and high. The interstitial space is filled with vesicles of differing sizes and in one or more series.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near

Fayetteville and Brentwood, Arkansas (Stations 134 and 145). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

BATOSTOMELLIDÆ

Genus STENOPORA Lonsdale

Stenopora tuberculata (Prout)

Plate IV, figures 3-5.

1859. *Flustra tuberculata.* Prout, Trans. St. Louis Acad. Sci., vol. 1, p. 447, pl. 17, figs. 3-3f.
Second Archimedes limestone: Barrett's Station, St. Louis County, Missouri.

1860. *Cyclopora polymorpha.* Prout, Trans. St. Louis Acad. Sci., vol. 1, p. 578.
Chester limestone: Pope County, Illinois.

1866. *Cyclopora polymorpha.* Prout, Geol. Surv. Ill., vol. 2, p. 421, pl. 21, figs. 5-5b.
Chester group: Pope County, Illinois.

1890. *Stenopora tuberculata.* Ulrich, Geol. Surv. Ill., vol. 8, p. 441, fig. 17; also fig. 5c, p. 315.
Chester group: Chester, Illinois.
St. Louis limestone and Warsaw beds.

1894. *Stenopora tuberculata.* Keyes, Mo. Geol. Surv., vol. 5, p. 15.
St. Louis limestone: Barrett Station, Missouri.
Kaskaskia limestone: Chester, Illinois.

1903. *Stenopora tuberculata.* Condra, Nebr. Geol. Surv., vol. 2, pt. 1, p. 42, pl. 4, fig. 6.
Coal Measures: Southbend, Nebraska.
Warsaw group: Bennett's Station, Missouri.
St. Louis group: several localities.
Chester group: Pope County and Chester, Illinois; Grayson Springs and Sloan's Valley, Kentucky.

1903. *Stenopora tuberculata.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 335.
Weber limestone: Crested Butte district, Colorado.

This well known and probably somewhat comprehensive species is represented in the Morrow collections by a number of specimens. In some the zoarium is an extremely thin, expanded crust attached to other organisms while in others it consists of laminar growths with a rugose epitheca on the under side varying in thickness from 0.5 to 1.5 mm. The surface is in all cases apparently smooth except for the tiny spine-like protuberances of the acanthopores when the preservation is excellent. The cell apertures are quite variable in size and shape

with from 15 to 18 occurring in the space of 5 mm.; interspaces thin. The zooecial tubes are comparatively short, prostrate below but soon becoming erect and proceeding directly to the surface of the layer; diaphragms numerous, ordinarily less than their diameter apart, perforated. Mesopores rarely present; acanthopores moderately large, generally present at the junction angles of the zooecial walls.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 134). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Stenopora sp.

Plate IV, figure 6.

A single, well-preserved specimen of another species of *Stenopora* was found in association with the form just described. It consists of a laminar expansion about a millimeter in thickness and apparently free. The surface is smooth except for the presence of low pyramidal spines at the junctions of the zooecial walls which are very thin. Apertures large, somewhat irregular in size and shape but commonly hexagonal or pentagonal, with angles very little rounded, and with only 11 or 12 zooecia occurring in the space of 5 mm. Zooecial tubes short, prostrate below but curving rapidly upward and proceeding directly to the surface of the zoarium; diaphragms apparently rare; mesopores exceptional; acanthopores commonly present at the junction angles of the walls.

The specimen is evidently representative of an undescribed species and is characterized by the large apertures accompanied by very thin zooecial walls.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 134).

Genus ANISOTRYPA Ulrich

Anisotrypa sp.

Plate IV, figures 7, 8.

Description. Zoarium a curved laminar expansion, probably a fragment of a large hollow branch, composed of several layers intergrown and lined with a thin epitheca. Apertures sub-circular, without conspicuous variation in size, 13 or 14 occurring

in 5 mm.; zooecial walls comparatively thick, ridge-like at the surface and finely granulose. Zooecial tubes short, prostrate below, becoming erect above, perforated diaphragms not numerous. Zooecial cavities sharply defined one from the other, mesopores and acanthopores absent.

Remarks. Although no representatives of this genus have hitherto been described from the Pennsylvanian strata of America, there is no doubt that the material at hand should be thus identified. It is evidently not referable to any of the Mississippian species.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 134).

FENESTELLIDÆ

Genus FENESTELLA Lonsdale

Fenestella serratula Ulrich

1890. *Fenestella serratula.* Ulrich, Geol. Surv. Ill., vol. 8, p. 544, pl. 50, figs. 5-5c.
Keokuk group: Nauvoo, Illinois
Warsaw beds: Monroe County and Warsaw, Illinois.
St. Louis limestone: Caldwell, Lyon, and Crittenden Counties, Kentucky.
Chester group: Sloan's Valley, Kentucky.

1894. *Fenestella serratula.* Keyes, Mo. Geol. Surv., vol. 5, p. 23.
Keokuk limestone: Keokuk, Iowa.

1911. *Fenestella serratula.* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 364, text fig. 5.
Maxville limestone: Kroft Bridge, White Cottage and Harper Shaft, Olive Furnace, Ohio.

This widespread and comparatively long-lived species of Fenestella is represented by numerous specimens from the Morrow group though strangely it has not been recognized in collections from the lowest horizon of the group. The material at hand is somewhat variable but typically there are 26 or 27 branches and 18 or 19 fenestrules in the space of a centimeter with 26 or 27 zooecial apertures in 5 mm. The median keel which separates the two rows of alternating apertures is slightly flexuous and when well preserved displays the serrate crest typical of the species. The dissepiments are possibly somewhat stronger and less depressed than those of the Mississippian individuals.

Horizon and locality. Brentwood limestone: Fayetteville (Station 148), and Baxter Mountain (Station 153), Arkansas. Morrow formation: near Ft. Gibson (Stations 296 and 301), and Choteau (Station 306), Oklahoma.

Fenestella venusta n. sp.

Plate IV, figures 9-10a.

Description. Zoarium an undulatory foliar expansion probably not over 2.5 cm. in length or breadth, composed of slender branches exceedingly closely spaced and united by short dissepiments at regular and frequent intervals. Branches bifurcating at irregular intervals; moderately rigid; rounded and longitudinally striated on the reverse, bearing a carinate median keel on the obverse; from 32 to 38, commonly about 36, in 10 mm. Dissepiments about two-thirds as wide as the branches, broadening at either end; very slightly depressed on the obverse, more strongly depressed on the reverse face. Fenestrules elongate oval in outline, slightly more elongate on the obverse than on the reverse face; very constantly 32 in 10 mm. longitudinally. Zooecia in two alternating rows generally arranged so that one occurs at the union of each dissepiment with the branch and one midway between the dissepiments; ranges separated by a slightly flexuous, carinate ridge bearing small nodes irregularly situated along its crest. Apertures circular, about 1 diameter apart in the rows, with about 32 or 33 occurring in the space of 5 mm.

Remarks. This very delicate form may be readily distinguished from previously described members of the genus by its closely spaced branches and small fenestrules. In the number of branches and fenestrules in a centimeter it very appreciably exceeds *F. tenax,* the most finely "woven" of the Mississippian species of *Fenestella.* From that form it may also be distinguished by its comparatively more robust dissepiments.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Brentwood (Station 145), and Fayetteville (Station 135), Arkansas. Kessler limestone: near Brentwood, Arkansas (Station 144). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Fenestella morrowensis n. sp.

Plate IV, figures 11, 11a.

Description. Zoarium an undulatory foliar expansion probably not exceeding 3 cm. in length or height, composed of rigid branches united at regular intervals by non-poriferous dissepiments. Branches bifurcating at irregular distances, rounded on the reverse, and bearing a strongly carinate, nodiferous, median ridge on the obverse; 14 or 15 branches in 10 mm. Dissepiments rounded on both faces, slightly expanded terminally, about one-half as wide as the branches. Fenestrules elongate sub-oval, broader on the reverse and with outline crenulated by the strong peristomes of the zooecial apertures on the obverse face; eleven in 10 mm. longitudinally. Zooecia in two alternating rows separated by a strongly carinate ridge along whose elevated summit small elongate nodes occur at intervals of about 0.5 mm. Apertures, 18 or 19 in 5 mm., typically 3 to each fenestrule with a fourth opposite the dissepiment; circular in outline, approximately one diameter apart in the rows; peristomes strongly elevated and complete; circular opercula present in well-preserved material.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137). Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Genus ARCHIMEDES Lesueur

Archimedes juvenis n. sp.

Plate IV, figures 12, 12a.

Description. Axis strong, from 5.0 to 5.7 mm. in diameter; volutions regular, 3¾ to 4¼ in 2 cm.; shaft and flange not sharply differentiated one from the other, the flange appearing simply as a spiral thickening of the shaft; the concavities between the flanges, although moderately deep, without a distinctly flattened floor to form the sides of the shaft; the slopes from the apex of the flange to the shaft sub-equal above and below so that in most specimens it is impossible to say with certainty which is the top and which the bottom of the spiral until the shaft has been sectioned; as seen in longitudinal section the lines

of zooecia, representing that portion of the fenestrated expansion which is enclosed in the solid axis, are very moderately convex upward and meet in the center at an obtuse angle, about 115°.

Remarks. Among the Mississippian *Archimedes* only one, *A. swallovanus*, displays a close resemblance to *A. juvenis* and from it the latter may be distinguished by the somewhat wider spacing of the volutions and the shape of the flanges which in the older forms are directed distinctly, though moderately, upward. The slight convexity of the lines of zooecia, seen in longitudinal section as mentioned above, seems also to be quite uncommon in an axis with so widely spaced volutions.

Horizon and locality. Brentwood limestone: Baxter Mountain and Fayetteville, Arkansas (Stations 153 and 148).

Genus POLYPORA MacCoy

Polypora triseriata n. sp.

Plate V, figures 2-3.

Description. Zoarium a foliar, fan-shaped, undulating expansion probably not over 4 cm. in height, composed of delicate, rounded, bifurcating branches united at regular intervals by somewhat depressed, rounded dissepiments whose diameter is about two-thirds that of the branches. Branches averaging 19 in 1 cm., but with as few as 17 or as many as 22 in places; about 0.4 mm. in width, expanding to a width of 0.6 mm. or even more at bifurcations; finely striated on the reverse side and somewhat flattened on the aperture-bearing surface. Fenestrules more or less oval, varying but little from 0.4 mm. in length but the width varying from 0.2 mm. to nearly as great as the length; 14 to 16 in 1 cm. longitudinally. Apertures circular, arranged in two, three, or four rows, almost invariably alternating, each row separated from adjacent rows by a faint, not noticeably nodiferous, sinuous ridge or keel; along any branch the three-rowed arrangement of the apertures is the normal manner with the median row prominently displayed along the flattened surface of the branch and the lateral rows partially concealed along its sides but for a distance of one or two, or even four millimeters immediately before a bifurcation, the additional row is added and over a similar space, after bifurcation has occurred, only two rows are present and the resemblance to *Fenestella* is strong;

from 21 to 23 apertures are present in each 5 mm. of longitudinal space, the individual apertures being separated by spaces one-half to two-thirds as great as their diameters.

Remarks. This species is comparable to only two of the previously described Carboniferous members of the genus, *P. whitei* and *P. biseriata.* From the former it is distinguished by the closer arrangement of the apertures, their relatively larger diameter, and the less elongated fenestrules as well as by the greater persistence of the triseriate arrangement of the zooecia. Like *P. whitei,* it may be considered as a link between *Fenestella* and *Polypora.* From *P. biseriata* this species is distinguished by the absence of the central row of nodes and by the fact that the arrangement of zooecia in three ranges is normal instead of rare, as in the Mississippian form.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: in the vicinity of Fayetteville, and near Brentwood, Arkansas (Stations 135, 148, 150, and 145).

Polypora elliptica Rogers

1900. *Polypora elliptica.* Rogers, Kans. Univ. Quart., vol. 9, p. 7, pl. 4, fig. 2.
Upper Coal Measures: Kansas City, Missouri; Argentine, Lawrence, and Topeka, Kansas.

1903. *Polypora elliptica.* Condra, Nebr. Geol. Surv., vol. 2, pt. 1, p. 69, pl. 11, figs. 4-11; pl. 12, figs. 1-13; pl. 16, fig. 3.
Coal Measures: Kansas City, Missouri; Argentine, Lawrence, and Topeka, Kansas; several localities, Nebraska.
Permian: Blue Springs, Nebraska.

A small fragment of a foliar, fan-shaped expansion from the Brentwood limestone seems to be indistinguishable from some of the forms included in this very variable species. As usual, the obverse face only is exposed. The branches are subcarinate, somewhat flexuous and about 2.5 mm. in width, with 14 to 16 occurring in the space of 1 cm. The dissepiments are the same shape and about half as wide as the branches and slightly depressed below them. The fenestrules are sub-oval to circular in outline, 0.3 to 0.4 mm. wide and 0.4 to 0.6 mm. long, with 12 or 13 to the centimeter. By grinding down the fragment it was ascertained that the zooecia are sometimes in two, but more

commonly in three ranges; apertures are circular and nearly two diameters apart in the rows. A fragment of a similar form from a second locality displays numerous small spines or nodes in rows between the zooecia as in the type material.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Polypora purduei n. sp.

Plate IV, figures 13-14.

Description. Zoarium a foliar, fan-shaped expansion, 2 or 3 cm. in height and somewhat undulating. Branches rigid, bifurcating at irregular intervals, 8 to 11 occurring in a space of 1 cm.; averaging 0.5 mm. in width but increasing to 0.7 or 0.8 mm. just before a bifurcation and decreasing to half that width immediately thereafter; convex and striated on reverse and convex to somewhat flattened on obverse face. Dissepiments somewhat depressed on either face, of nearly the same thickness from branch to branch as observed on the reverse side but increasing in width terminally as seen from the obverse face, averaging 0.35 mm. in width but in some instances only 0.2 mm., or again as great as 0.45 mm. Fenestrules about twice as long as wide, subquadrate on the reverse and sub-oval on the obverse face, 6 or 7 to the centimeter longitudinally, and varying in length from 0.8 to 1.1 mm. Zooecia arranged in four or five rows increasing to six or seven before and decreasing to three after bifurcation, 20 or 21 occurring in a space of 5 mm.; the apertures circular, separated by about twice their diameter in the rows; very faint, sinuous, rounded ridges separate the ranges as observed on unweathered surfaces and in places a slight elevation suggestive of a node may develop along the ridges near the middle of the branch.

Remarks. This species falls into a group of mid-Carboniferous *Polyporas* which are closely alike in characteristics and presumably intergrade rather freely one to the other. It may be distinguished from *P. bassleri* by the absence of the small spines on the poriferous side of the branches and by the smaller number of fenestrules to the centimeter resulting from the slightly greater width of the dissepiments. From *P. cestriensis* it is dis-

tinguished by its smaller and less elongated fenestrules, its stouter dissepiments and broader branches, and the somewhat closer spacing of the zooecial apertures. In comparison with *P. corticosa* the absence of the zooecial filling near the base of the zoarium, the proportionately narrower fenestrules, and the broader branches may be noted. Comparing *P. purduei* with *P. fastuosa,* a distinguishing characteristic is the lesser prominence of the dissepiments, which in the latter species are carinate and as high as the branches as well as less than a third their width. From *P. ulrichi* this species is distinguished by the closer spacing of zooecial apertures, the less elongated fenestrules, and the absence of nodes on the reverse face.

It is noteworthy that each of these five species is recorded from the Coal Measures except *P. corticosa,* a Chester form with which *P. cestriensis* also occurs, so that the form under discussion is in a sense transitional between the Chester and Coal Measures types with its affinities closer to the latter than to the former.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Station 135) ; Sawney Hollow, Oklahoma (Station 210). Morrow formation: vicinity of Ft. Gibson, Oklahoma (Stations 301 and 303).

Polypora washingtonensis n. sp.

Plate IV, figures 15, 15a.

Description. Zoarium a foliar, fan-shaped expansion, 2 or 3 cm. in height, undulating or regularly curved transversely, with the apertures on the inside. Branches strong, rigid as observed from the obverse and slightly flexuous as seen from the reverse side, sub-triangular in cross-section; 0.1 or 0.2 mm. in width on the reverse face of the zoarium and 0.7 or 0.8 mm., or even 1.0 mm. below bifurcations, in width on the poriferous side; 8 to 10, usually 9 to the centimeter. Dissepiments sub-carinate, with cross-section similar to that of the branches; slightly depressed below either face; 0.1 mm. wide near the reverse face and 0.6 or 0.7 mm. wide near the obverse face where they are much wider at the ends than midway between the branches. Fenestrules sub-quadrate as viewed from the non-poriferous side, very reg-

ularly 0.7 by 0.8 mm. in lateral dimensions; sub-circular to sub-oval in outline on the obverse face, 0.3 to 0.4 mm. by 0.2 to 0.3 mm. in longitudinal and transverse diameter; quite constantly 9 to the centimeter longitudinally. Zooecia arranged in four rows increasing to five or six before bifurcations and for short distances thereafter decreased to three; apertures circular, fairly closely spaced, separated by one to one and a half diameters in the ranges, 21 or 22 occurring in a space of 5 mm.; ranges probably not separated by ridges or rows of tubercles.

Remarks. This species displays a close affinity to *P. nodocarinata* of the Upper Coal Measures but is distinguished from it by the more strongly carinate branches as seen on the reverse side and by the absence of the rows of tubercles on the obverse face between the zooecial ranges. In the shape of the branches it is comparable to *P. triangularis* but is sharply differentiated from that form by the shape of the fenestrules and the absence of the nodes on the reverse face.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: East Mountain, Fayetteville, Arkansas (Station 150). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Polypora constricta n. sp.

Plate IV, figures 16-17.

Description. Zoarium a funnel-shaped or foliar undulating expansion composed of strongly carinate, nearly rigid branches united at regular intervals by dissepiments sub-equal to the branches in shape and width. Branches triangular in cross-section, 8 or 9 in a centimeter, carinate, 0.3 to 0.5 mm. wide on the reverse face with an occasional small, rounded tubercle which is situated at the point of junction with the dissepiments; broadly convex and wider, 0.8 to 1.1 mm., on the poriferous side where the surface is finely rugose and a row of small spines, 0.3 to 0.4 mm. apart, is present along the median line of many of the branches. Fenestrules sub-quadrate or sub-polygonal, with rounded corners on the reverse where their dimensions are close to 1.0 mm. in either direction; constricted toward the obverse side of the frond by the widening of branches and dissepiments so that they have a circular or sub-oval outline and a length and

width of only 0.2 or 0.25 mm.; 6½ or 7 occur in a centimeter. Dissepiments of the same shape and nearly or quite as strong as the branches, 1.1 or 1.2 mm. in width on the obverse side and only 0.25 or 0.3 mm. long between the zooecial ranges of the adjacent branches. Zooecia in 4 or 5 ranges increasing to 6 or 7 before bifurcation and decreasing to 3 immediately thereafter; apertures rather large, circular, about 1½ diameters apart in the rows, 15 or 16 occurring in the space of 5 mm.; peristomes prominent.

Remarks. The strong carinate branches and dissepiments, which give the fenestrules, as observed from the reverse face of the zoarium, the appearance of deep, funnel-shaped pits constricted below, serve readily to distinguish this species from others of the genus.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: Maple Street, Fayetteville, Arkansas (Station 148). Morrow formation: near Ft. Gibson (Station 296), and Hulbert (Station 299), Oklahoma.

Polypora halensis n. sp.

Plate VI, figures 3, 3a.

Description. Zoarium an undulating, fan-shaped, reticulating expansion composed of comparatively delicate, bifurcating branches united at regular intervals by slender dissepiments. Branches somewhat flexuous, especially as viewed from the reverse side, where they are about 0.2 mm. wide midway between dissepiments and broader at the points of union, ornamented by small rounded nodes irregularly placed along the sub-carinate, non-poriferous face and varying in number from 0 to 4 to the fenestrule; obverse face of the branches broadly convex, from 0.5 to 1.0 mm. in width, 7 or 8 branches occurring in 1 cm. Fenestrules sub-polygonal on the reverse where their diameters are from 0.9 to 1.1 by 0.6 to 0.9 mm.; smaller and sub-oval, 0.7 to 1.0 by 0.3 to 0.6 mm. on the obverse face of the frond; usually 7 to the centimeter longitudinally, not arranged in oblique rows. Dissepiments shaped the same as the branches but somewhat more slender. Zooecia in 4 or 5 ranges, increasing to 7 before bifurcation; apertures circular, about two diameters apart in the rows, 20 or 22 occurring in 5 mm.

Remarks. The approximate equality between the number of branches transversely and of fenestrules longitudinally in a unit distance and the presence of nodes along the reverse side of the branches are the distinguishing features of this species. In comparison with *P. ulrichi* of the Coal Measures the greater number of zooecial apertures in a unit space along the branches is also noteworthy.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Polypora magna n. sp.

Plate V, figures 1, 1a.

Description. Zoarium an undulating, fan-shaped expansion attaining a length of at least 9 cm. and a width of 7 cm., composed of rigid, bifurcating branches united at regular intervals by strong dissepiments. Branches somewhat flattened on the reverse face and hence moderately sub-angular at either side; coarsely granulose, about 0.7 or 0.8 mm. in width but increasing to 1.4 mm. below a bifurcation and decreasing to 0.5 mm. immediately thereafter, as observed on the non-poriferous face of the frond; typically 6 in a centimeter; obverse face of the branches broadly convex, the branches a little wider there than on the other side. Fenestrules sub-oval in outline, 4½ to 5 occurring in a centimeter, somewhat larger, 0.8 to 1.2 by 1.2 to 1.4 mm., on the reverse face than on the obverse, 0.6 to 0.7 by 1.0 to 1.2 mm., but shaped much the same on either side of the frond. Dissepiments nearly as wide as the branches and similarly shaped on the non-poriferous face of the zoarium but not increasing in width toward the opposite side as do the branches. Zooecia arranged in 6 or 7 rows increasing to as many as 10 below bifurcations and decreasing to 5 immediately thereafter; apertures circular, separated by a space of 2 or more diameters in the ranges, about 16 or 17 occurring in 5 mm.

Remarks. This, the largest of the Morrow *Polyporas,* is quite distinct from the others here described and may be compared with only one of the previously known members of the genus, *P. submarginata.* From that species it is readily distinguished by its less elongated fenestrules and the absence of spines between the zooecial apertures. The large number of zooecial

ranges is in keeping with the generally robust nature of the zoarium.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Brentwood, Arkansas (Station 145).

Polypora kesslerensis n. sp.

Plate V, figures 6, 6a.

Description. Zoarium an undulating, reticulated expansion composed of bifurcating branches united by short, broad dissepiments at regularly alternating intervals. Branches broadly convex on the obverse face, slightly flexuous; 0.8 to 1.0 mm. in width, increasing to 1.3 mm. below a bifurcation; ordinarily 7 in the space of a centimeter. Fenestrules oval, 0.6 to 0.7 by 0.9 to 1.0 mm. in size, 5½ to 6 occurring in a centimeter longitudinally, arranged also in oblique rows where about 4½ are found in the same distance. Dissepiments slightly depressed below the poriferous surface, comparatively short and broad, gently convex longitudinally, slightly concave transversely; 0.7 to 1.6 mm. in width and 0.2 to 0.5 mm. long between the ranges of zooecia which in many cases encroach somewhat from the adjacent branches upon the ends of the dissepiments. Zooecia in five or six, or even as many as seven ranges, 18 or 19 in the space of 5 mm. longitudinally, the ranges distinctly sinuous, apertures circular, 1½ to 2 diameters apart in the longitudinal rows. Reverse not known.

Remarks. Like that of *P. complanata,* the zoarium of this species has more the appearance of a "rhythmically perforated plate" than of a network with distinct branches. From that form *P. kesslerensis* is distinguished by its comparatively larger fenestrules and more slender branches. It is, perhaps, intermediate between *P. complanata* and the two species to be next described which approach in characteristics the members of the genus *Phyllopora.*

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Polypora reversispina n. sp.

Plate V, figures 4, 4a.

Description. Zoarium a funnel-shaped, reticulated expansion composed of bifurcating branches united at regular intervals by short dissepiments, with the zooecial apertures on the inner face. Branches broadly convex and flexuous on the obverse, sub-carinate and more rigid on the reverse face; 0.8 to 1.0 mm. in width on the poriferous, 0.3 to 0.4 mm. wide on the non-poriferous side; 9 to 10 occurring in the space of 1 cm.; ornamented on the reverse by numerous small, hollow, rounded spines or tubercles irregularly situated but commonly with three or four to a fenestrule. Fenestrule sub-quadrate or sub-hexagonal on the reverse, oval and much smaller on the obverse, 6 or 7 in a centimeter longitudinally, 1.0 to 1.2 by 0.7 to 0.8 mm. on the reverse face and 0.3 by 0.4 mm. on the obverse. Dissepiments short, as wide as or wider than the branches; convex or somewhat flattened, on a level with or slightly depressed below the surface of the zoarium on the non-poriferous side; shorter and broader toward the obverse face with but a narrow strip of non-poriferous substance remaining between the almost anastomosing branches and in some instances even this disappearing so that the fenestrules are completely surrounded by apertures. Zooecial apertures arranged in 4 or 5, or in places 6 alternating ranges which are distinctly sinuous; apertures small, circular, a diameter and a half apart longitudinally and less than a diameter apart obliquely, about 21 in 5 mm.

Remarks. Like *P. transiens* of the Salt Range, *P. reversispina* may be considered as transitional between the genera *Polypora* and *Phyllopora.* It is placed with the former because of its reticulated appearance with distinct dissepiments, as viewed from the reverse side, and because the zooecial apertures are situated on the inside rather than the outside of the "funnel" although on its poriferous side it must resemble *Phyllopora* more than *Polypora.*

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Polypora anastomosa n. sp.

Plate VI, figures 4, 4a.

Description. Zoarium a funnel-shaped or foliar, reticulated expansion composed on the reverse of flexuous, somewhat irregular branches, united by broad dissepiments, in such a way that individual branches can be traced only with great difficulty while on the obverse the branches are practically anastomosing. Branches massive, irregularly sub-carinate, granulose, 0.4 to 0.8 mm. wide on the reverse; broadly convex, 1.0 to 1.3 mm. wide on the obverse; about 6 to a centimeter transversely. Fenestrules sub-polygonal to sub-oval on the reverse, 1.1 to 1.5 by 0.8 to 1.3 mm. in diameter, 3½ to 4 in a centimeter longitudinally; smaller on the obverse, oval in shape and usually about 0.8 by 0.5 mm. in size. Dissepiments of variable length depending upon the sinuosity of the branches, but typically less than 1.0 mm. long and about 1.5 mm. wide on the reverse; shorter and broader on the obverse where they average 2.0 mm. in width and are less than 0.5 mm. long, and the zooecial apertures encroach upon them from the adjacent branches until in some instances no non-poriferous portion remains. Zooecia in 5 to 7 flexuous rows, in some instances increasing to 9 or decreasing to 4; apertures small, circular, about 20 in 5 mm. in the ranges and separated by spaces about twice as great as their diameters.

Remarks. The forms placed under this head are to be grouped with *P. reversispina* as transitional between the genera *Polypora* and *Phyllopora*. Resemblances to *P. transiens* are close but the two species are readily distinguished by the more flexuous branches and wider dissepiments of the Morrow form.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 135 and 150).

Polypora anastomosa var. **spinicarinata** n. var.

A fragment of a frond from the same locality as that which supplied the type of *P. anastomosa* seems to represent a distinct variety of that species. The arrangement of the zooecial apertures is the same as in the half dozen specimens of the typical variety but from them it differs in the generally more robust nature of the branches and dissepiments and in the presence of

a distinct row of small circular spines, commonly about three to a fenestrule, along the middle of the sub-carinate reverse side of the branches. The branches are, also, somewhat more rigid and distinct than in the typical variety.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Genus PHYLLOPORA King

Phyllopora perforata n. sp.

Plate V, figures 5, 5a.

Description. Zoarium a rapidly expanding, probably somewhat funnel-shaped, reticulated expansion composed of anastomosing branches so completely intergrown that the whole appears as a plate perforated at fairly regular intervals by oval fenestrules arranged in more or less definite rows. Rows of fenestrules separated by spaces 0.7 to 0.9 mm. in width; in the rows the fenestrules are about 1.3 to 1.5 mm. apart, typically 6 of them occurring in a distance of 10 mm.; fenestrules comparatively small, oval in shape, 0.3 to 0.45 mm. wide, 0.4 to 0.7 mm. long. Zooecial apertures scattered over surface of frond without definite arrangement either in longitudinal or oblique ranges; not present in a space about 0.15 mm. wide which forms the periphery of each fenestrule; apertures small, circular, about 20 to 22 occurring in a square millimeter. Zoarium thickened at the base and zooecial apertures closed in the thickened region as in *Polypora corticosa.*

Remarks. Only one fragment, about 13 by 12 mm. in size, of this species is present in the Morrow collections but its characteristics as described above distinguish it sharply from all described Carboniferous bryozoa of North America and it is referred with considerable confidence to the genus *Phyllopora* represented by several species in the Permian of Great Britain and India as well as by a few Silurian and Devonian forms. Two discrepancies ought, however, to be noted in the comparison of the material at hand with King's diagnosis[42] of his genus and its interpretation by Waagen and Pichl.[43] The first, which may be of some importance, is that in *P. perforata* the zooecial cavities ascend obliquely from the non-poriferous side to the obverse face and are not approximately vertical to the latter as they are in

P. ehrenbergi, the type species. The second, of minor importance, is in regard to the shape of the zoarium. Waagen and Pichl insist upon the funnel-shaped form of the colony although King defines it as "consisting of infundibuliform, folded, perforated fronds or foliaceous expansions." The fragment at hand may possibly be a portion of a funnel-shaped colony though if so, it was not nearly so cornucopia-like as the type species or as the best preserved of the Salt Range Phylloporas, but it is more likely a part of a "foliaceous expansion."

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Phyllopora cribrosa n. sp.

Plate VI, figures 5, 5a.

Description. Zoarium a foliar expansion composed of sinuous branches united at regular intervals by poriferous dissepiments into a rhythmically perforated plate. Branches regularly rounded, a little more strongly convex on the reverse than on the obverse face, 0.5 to 0.7 mm. wide on the former, 0.6 to 1.0 mm. in width on the latter side, about 6 occurring in a centimeter; small nodiferous protuberances are scattered irregularly over the reverse face of the frond. Dissepiments the same shape as the branches and nearly or quite as strong, depressed somewhat below either face of the zoarium and expanded terminally; situated at right angles to the general trend of the branches. Fenestrules regularly hexagonal in outline with rounded corners, 1.2 to 1.3 by 1.0 to 1.2 mm. in size, on the reverse; oval in shape on the obverse face where they are somewhat narrower; 5½ occur in 1 cm. Zooecia in 4 to 6 slightly irregular ranges on the branches and with 5 or 6 apertures on each dissepiment; the apertures not confined to the obverse face of the branches and dissepiments but encroaching laterally upon their regularly curved sides and with prominent peristomes thus giving the fenestrules a scalloped outline in the sections parallel and adjacent to the poriferous side of the zoarium; apertures circular, 2 or more diameters apart in the rows, 17 or 18 occurring in 5 mm.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 296).

ACANTHOCLADIIDÆ

Genus SEPTOPORA Prout

Septopora reversispina n. sp.

Plate VI, figures 2, 2a.

Description. Zoarium an undulating foliar expansion composed of rigid branches united at regular intervals by slender poriferous dissepiments into a compact network. Branches increase in number by interpolation with 10 occurring in each centimeter transversely; on the reverse they are narrowly rounded, 0.2 to 0.4 mm. in width, and ornamented by round, more or less pointed spines projecting slightly downward and generally situated opposite each junction with a dissepiment; on the obverse the branches are somewhat broader. Dissepiments rounded, more slender than the branches and depressed below them, arched across the space between the branches and expanded terminally. Fenestrules subquadrate on the reverse, 10 to the centimeter, 0.6 to 0.8 mm. long and 0.4 to 0.7 mm. wide, more oval and smaller on the obverse. Zooecia in 2 ranges along the branches, about 25 occurring in the space of 5 mm., 5 or 6 on each dissepiment; accessory pores on the reverse face small, about 0.04 mm. in diameter, usually one or two situated near either end of each dissepiment.

Remarks. Distinguishing features of this species are the equality in the number of branches and fenestrules in a unit distance, the increase in the number of branches by interpolation, and the presence of spines on the reverse face of the frond. None of the previously described members of the genus appear to be closely comparable to it.

Horizon and locality. Brentwood limestone: near Brentwood, Arkansas (Station 145).

Septopora crebripora n. sp.

Plate VI, figures 1, 1a.

Description. Zoarium a compact, foliar, fan-shaped network composed of bifurcating branches united at regular intervals by poriferous dissepiments. Branches rigid, 10 or 12 to the centimeter, 0.3 to 0.4 mm. in width on the reverse, increasing to 0.6 or 0.7 mm. before bifurcation and as narrow as 0.2 mm. for short

spaces immediately thereafter, rounded and longitudinally striated; on the obverse face the branches are very little wider and are marked by a distinct mesial keel separating the two ranges of zooecia. Dissepiments typically slightly narrower than the branches, and depressed somewhat below them; at right angles to the branches and broadening at the ends in the basal portion of the zoarium, more frequently oblique in the outer portions. Fenestrules 9½ or 10 to the centimeter, oval or circular toward the base of the frond, ordinarily subquadrate or diamond-shaped toward the upper margin, 0.4 to 0.6 mm. long and 0.3 to 0.6 mm. wide, size and shape similar on either face of the zoarium. Zooecia in 2 ranges separated by a median keel, on the branches; 3 to 6, commonly 4, on each dissepiment; apertures circular and closely adjacent in the rows, 27 or 28 occurring in 5 mm. along the branches. Accessory pores numerous on the reverse face of the frond, generally 4, but varying from 2 to 5, on each dissepiment situated more commonly in pairs at either end; about 0.1 mm. in diameter.

Remarks. This species displays many resemblances to *S. cestriensis*, common in the Chester of the Mississippi valley and identified by Condra from the Coal Measures of Nebraska, but from that form it is distinguished by its somewhat larger fenestrules and more numerous accessory pores as well as by the greater number of zooecial apertures in a unit distance. Unfortunately the only specimen at hand is not preserved so as to permit the determination of the presence or absence of nodes along the mesial carina.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Septopora implexa n. sp.

Plate VI, figure 12.

Description. Zoarium a foliar expansion composed of primary and secondary branches united at more or less regular intervals by poriferous dissepiments into an undulating network. Primary branches 0.6 to 0.8 mm. in width, nearly rigid, giving off secondary branches by lateral division at an angle of about 35° and typically with 8 branches in a centimeter; secondary branches 0.4 to 0.6 mm. in width and connected by arching dis-

sepiments, 9 or 10 of which occur in a centimeter; reverse face of branches striated and irregularly rounded with nodiferous swellings occurring at unequal distances along the middle. Dissepiments arching or sub-angular as though formed by the union of pinnae given off from adjacent branches, depressed somewhat below the level of the branches on the reverse side, slightly narrower than the secondary branches and expanded terminally. Fenestrules varying in shape from oval through sub-quadrate to sub-crescentic, from 0.5 by 0.4 to 0.9 by 0.5 mm. in size, and from 7 to 10 in 1 cm. Zooecia normally in two alternating ranges along branches and dissepiments, with 17 or 18 in 5 mm. on the former and from 4 to 6 on each of the latter; accessory pores on the reverse side, small, ordinarily with 2 situated at either end of each dissepiment though in many cases one or both may be absent. Obverse not known.

Remarks. This form is comparable to but one of the previously described members of the genus, *S. biserialis-nervata.* It is distinguished from that species by the greater angle between primary and secondary branches, the nodiferous irregularities of the reverse side of the branches, and the smaller number of zooecia in unit distance.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 134).

Genus ACANTHOCLADIA King

Acanthocladia sp.

Three fragments of a bryozoan, preserved in large part as impressions in shale, although indeterminable specifically, are referred confidently to the genus *Acanthocladia.* The zoarium consists of a narrow stipe 0.7 to 0.9 mm. in width giving off at regular intervals pinnate branches which are commonly, though not invariably, alternating. The pinnae, 7 of which occur in 1 cm., are 0.4 to 0.6 mm. wide and 2 to 3 mm. long. Zooecia in 3 ranges on the pinnae and probably in 5 ranges on the central stipe.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 296).

Genus DICTYOCLADIA n. gen.

Description. Zoaria poriferous on one side only, pinnate or loosely fenestrated expansions consisting of primary branches with numerous lateral branches proceeding obliquely from their opposite margins, some of which may be nearly or quite as strong as the primaries and in turn give off lateral branches; lateral branches united at intervals by the union of non-poriferous pinnae from adjacent branches. Zooecia in three or more rows along primary and lateral branches; reverse or non-poriferous side with scattered dimorphic pores.

Remarks. Dictyocladia differs from *Ptilopora* in that the zooecia occur in more than two ranges. Like *Septopora* it is characterized by the presence of accessory pores on the reverse side of the branches.

Genotype: Dictyocladia triseriata n. sp.

Dictyocladia triseriata n. sp.

Plate VII, figures 10, 10a.

Description. Zoarium a loosely reticulated expansion consisting of primary, secondary, and tertiary branches connected by occasional non-poriferous dissepiments. Primary branches rigid, 0.7 to 0.9 mm. in width; secondary branches proceeding from them laterally, generally alternately, 6 or 7 in a centimeter on either side, at an angle of 50° to 60°, normally about 0.5 mm. in width but with about one in four as strong as the primary branches; these in turn give rise to tertiary branches similar to the intermediate secondary ones; branches broadly rounded on the reverse and longitudinally striated, gently convex on the obverse face. Dissepiments somewhat irregularly situated, proceeding obliquely across the space between adjacent parallel branches and giving rise to trapezoidal or rhomboidal fenestrules; dissepiments averaging 0.2 mm. in width and 0.8 mm. in length, expanded terminally; 5 or 6 fenestrules in 1 cm. Zooecia in 3 ranges along the branches, dissepiments commonly non-poriferous, apertures circular, 2 or more diameters apart in the rows, 17 or 18 in 5 mm.; small circular accessory pores scattered irregularly over the reverse side of the branches.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Station 135).

RHABDOMESONTIDÆ

Genus RHOMBOPORA Meek

Rhombopora lepidodendroides Meek

Plate VI, figures 8, 9.

1866. *Stenopora columnaris.* Geinitz (part), Carb. und Dyas in Nebr., p. 66. (Not Schlotheim 1813).
Nebraska City, Bennett's Mill and Wyoming, Nebraska.

1872. *Rhombopora lepidodendroides.* Meek, U. S. Geol. Surv. Nebr., p. 141, pl. 7, figs. 2a-f.
Upper Coal Measures: Nebraska City, Bennett's Mill, Wyoming, Rock Bluff, and Plattsmouth, Nebraska; Kansas; Iowa; Missouri; Illinois.

1877. *Rhombopora lepidodendroides.* White, U. S. Geog. Surv. w. of 100th Merid., vol. 4, p. 99, pl. 6, figs. 5a-d.
Carboniferous: West face of Oquirrh range, near "E. T. City," Utah, and at confluence of White Mountain and Black Rivers, Arizona.

1884. *Rhombopora lepidodendroides.* Ulrich, Jour. Cinn. Soc. Nat. Hist., vol. 7, p. 27, pl. 1, figs. 1-1b.
Upper Coal Measures: Kansas City, Missouri; Nebraska City and Wyoming, Nebraska.

1887. *Rhombopora lepidodendroides.* Foerste, Bull. Sci. Lab. Den. Univ., vol. 2, p. 73, pl. 7, figs. 3a-b.
Coal Measures: Flint Ridge and Bald Hill, Ohio.

1887. *Rhombopora* ——————. Foerste, Bull. Sci. Lab. Den. Univ., vol. 2, p. 74, pl. 7, figs. 5a-c.
Coal Measures: Flint Ridge, Ohio.

1888. *Rhombopora lepidodendroides.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 225.
Lower Coal Measures: Des Moines, Iowa.

1894. *Rhombopora lepidodendroides.* Keyes, Mo. Geol. Surv., vol. 5, p. 35, pl. 33, figs. 4a-b.
Upper Coal Measures: Kansas City, Missouri.

1897. *Rhombopora lepidodendroides.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 237.
Upper Coal Measures: Poteau Mountain, Indian Territory.

1903. *Rhombopora lepidodendroides.* Condra, Nebr. Geol. Surv., vol. 2, pt. 1, p. 99, pl. 6, figs. 2-4; pl. 7, figs. 1-12.
Coal Measures: Various localities in Nebraska, Kansas, Missouri, Iowa, Illinois, and Ohio.

1903. *Rhombopora lepidodendroides.* Girty, Prof. Paper, U. S. Geol. Surv. No. 16, p. 314.
Grand River region, Colorado; Uinta Mountain region, overlooking Tampa River, Colorado.
Molas formation and middle portion of Hermosa formation: San Juan region, Colorado.
Base of Weber formation: Leadville district, Colorado.

1908. *Rhombopora aff. R. lepidodendroides.* Girty, Prof. Paper, U. S. Geol. Surv., No. 58, p. 153, pl. 31, fig. 17.
Delaware Mountain formation: Mountains northwest of Marathon, Texas.

1914. *Rhombopora lepidodendroides ?* Price, West Va. Geol. Surv., Preston County Rep., p. 490.
Pine Creek and Brush Creek limestones: Preston County, West Virginia.

Description. Zoarium a ramose, cylindrical, remotely bifurcating branch with a diameter of about 1.2 mm., the largest fragment seen having a diameter of 1.6 mm. and the smallest, 0.9 mm. None of the specimens at hand have a length greater than 1 cm. and none shows more than one bifurcation. Zooecia regularly arranged in quincunx, forming vertical, transverse, and intersecting spiral series around the branch, with typically seven apertures in each single vertical row in a space of 3 mm. Apertures broadly elliptical, opening into distinctly impressed and expanding vestibules with rhombic outlines; interspaces between the rhombic vestibules forming rounded or subangular ridges which are occupied by a single, or in some instances a double, row of small spiniform tubuli, with one much larger spine generally present at the junction angles of the ridges. The size of all the spines depends apparently upon the state of preservation and the small spines are generally very inconspicuous or not apparent.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Rhombopora tabulata Ulrich

Plate VI, figure 11.

1890. *Rhombopora tabulata.* Ulrich, Geol. Surv. Ill., vol. 8, p. 658, pl. 70, figs. 2-2c.
Chester group: Kaskaskia and Chester, Illinois; Sloan's Valley, Kentucky.

1894. *Rhombopora tabulata.* Keyes, Mo. Geol. Surv., vol. 5, p. 34.
Kaskaskia limestone: Ste. Genevieve, Missouri.

Ulrich's description. "Zoarium a cylindrical stem from 1 to 1.5 mm. in diameter branching dichotomously at intervals of 10 mm. more or less. Zooecial apertures ovate, averaging 0.18 mm. in length, from one-half to two-thirds as wide, arranged in irregular series, with the transverse and diagonal lines less frequently dominant than the longitudinal. On an average five

apertures occur in 2 mm. transversely and from twelve to fourteen in 5 mm. longitudinally. Measuring diagonally, seven is the usual number in 2 mm. Interspaces carinate, as wide as or wider than the zooecia apertures, carrying at most of the angles of junction a moderately large tubercle. Sloping areas varying considerably in form, being sometimes hexagonal and at other times pentagonal, lozenge-shaped, or irregularly quadrate."

Remarks. Numerous fragments at hand represent a form which seems to be indistinguishable from the species which Ulrich has thus described. The stems are, if anything, slightly more robust as some of them attain a diameter of 1.7 mm. and the vestibules into which the zooecial apertures open may be on the average a very little larger than those in the type specimens. Longitudinal sections show that diaphragms are present, though not in abundance, in the axial or primitive portion of the zooecial tubes.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Rhombopora snideri n. sp.

Plate VI, figures 6, 7.

Description. Zoarium a ramose, cylindrical branch, not dividing dichotomously but throwing off lateral branches at right angles to the main stem which has a diameter of from 1.4 to 1.6 mm. Interval between branches not known as none of the specimens in hand display more than one branch; the longest of the fragments is 13 mm. in length. Zooecia arranged fairly regularly in vertical, transverse, and diagonally intersecting, spiral series; 6½ or 7 apertures occur in a single vertical series in the space of 3 mm.; the alignment of the zooecia not rarely disturbed. Apertures sub-circular to broadly elliptical, opening into a vestibule which is generally hexagonal but in some instances rhombic in outline, with angles somewhat rounded. The ridges between the vestibules are rounded, rarely sub-angular, and ornamented with numerous small tubuli scattered irregularly over the surface or arranged in three fairly distinct rows, the median one of which is situated along the crest of the ridge and is commonly obliterated by weathering; a single, somewhat larger and stronger tubulus is normally situated at the junction angles of the walls.

Remarks. In its mode of branching this form resembles *R. persimilis*, of the Chester group, but may be readily distinguished from it by its more robust form. The appearance of the tubuli along the interspaces between the vestibules will readily serve to separate this species from others of the genus.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Rhombopora attenuata Ulrich

Plate VI, figure 10.

1890. *Rhombopora attenuata.* Ulrich, Geol. Surv. Ill., vol. 8, p. 655, pl. 70, fig. 7.
Keokuk group: Warsaw, Illinois.

1894. *Rhombopora attenuata.* Keyes, Mo. Geol. Surv., vol. 5, p. 34.
Keokuk limestone: Warsaw, Illinois.

Description. Zoarium a slender stem, 0.6 to 0.9 mm. in diameter, branching dichotomously at unknown but doubtless comparatively remote distances. Zooecial apertures arranged regularly in longitudinal and diagonal series, the former the more obvious. Apertures oval, opening into an elongate vestibule typically hexagonal in outline, due to the truncation of the rhombic area at either end; about 16 apertures in 5 mm. longitudinally. Interspaces moderately thin, acutely ridge-like, ornamented with a single row of very small and closely-set nodes along the summit; the nodes at the junction angles commonly somewhat larger than the others.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

CYSTODICTYONIDÆ

Genus CYSTODICTYA Ulrich

Cystodictya brentwoodensis n. sp.

Plate VII, figures 1, 1a.

Description. Zoarium consisting of bifoliate branches, elongate elliptical in cross-section, dividing dichotomously at intervals of about 10 mm. and varying in width from 3.2 to 3.5 mm. with an increase to as much as 6 mm. immediately before bifurcations. Zooecia in moderately definite longitudinal series,

typically 8 in number but increasing to 13 or 14 before a bifurcation, the ranges slightly sinuous and rarely separated by a faint discontinuous ridge, 12 or 13 apertures occurring in 5 mm.; in places an indefinite oblique arrangement may be observed and still more rarely the apertures in the three lateral rows on either side are grouped into curving lines with a roughly pinnate arrangement; non-poriferous margin comparatively wide. Apertures circular, peristomes complete, strongly elevated and thin when well-preserved, not so high and thicker on worn specimens.

Remarks. Only two of the previously described American species of *Cystodictya* are reported to have branches as broad as those of the individuals referred to this species. *C. carbonaria* of the Coal Measures is even more robust than the material at hand and has an appreciably larger number of zooecia in a unit distance. *C. simulans* of the Keokuk limestone is on the contrary more slender than *C. brentwoodensis* and is further distinguished by its more widely separated zooecial apertures with strongly elevated and thick peristomes. The comparatively broad non-poriferous margins of the Brentwood form are also noteworthy.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 135 and 148).

Cystodictya sinuomarginata n. sp.

Plate VII, figures 11, 11a.

Description. Zoarium composed of ramose bifoliate branches with pinnate projections along the margins which in some instances develop into secondary branches. Branches from 2.0 to 2.7 mm. in width, elongate sub-elliptical in cross-section; lateral projections variable in outline but occurring quite regularly 4 to a centimeter on either side, varying from regular sinuosities in which the convex outline of the projection is the counterpart of the concave interspace and the whole projection is only 0.8 mm. in length, to small branchlets, 1.2 to 1.4 mm. in width and nearly 2 mm. in length, directed somewhat obliquely outward from the primary stipe; the latter may develop into secondary branches nearly or quite as wide as the primary ones and having similar sinuous margins. Zooecia in 6 to 8 ranges separated by fine

but distinct longitudinal costae, with a variable number of zooecia, normally arranged in curving linear series, upon the pinnate projections; apertures subcircular; small, 11 or 12 occurring in 5 mm. along the longitudinal ranges, peristomes faint.

Remarks. The large size of the branches and their sinuous margins sharply distinguish this species from the other members of the genus. It is not closely comparable to any of the previously known Carboniferous forms.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone, near Fayetteville, Arkansas (Station 135).

Cystodictya flexuosa n. sp.

Plate VII, figures 8-9a.

Description. Zoarium consisting of ramose, bifoliate, flexuous branches with an elongate elliptical cross-section. Branches are from 2.0 to 2.5 mm. in width and divide laterally at intervals of 3 to 5 mm.; margins modified by short rounding protuberances occurring at irregular distances which, when present on both margins opposite each other, increase the width of the branch to 3.0 mm. or even more. Zooecia arranged in indefinite longitudinal and oblique series, with seven or eight of the former on each face of the zoarium; five or six apertures are clustered upon the lateral protuberances when they are present; the non-poriferous marginal portion of the branches very narrow. No longitudinal ridges are observable but in some instances an indefinite oblique furrow is present between the apertures, especially when the oblique serial arrangement is more perfect. Apertures oval or circular, 11 or 12 in 5 mm. longitudinally, oblique and with strongly elevated, rather thin peristomes when the preservation is good; appearing more nearly perpendicular to surface and with less elevated but thicker peristomes when somewhat worn.

Remarks. *C. zigzag* from the Keokuk limestone is probably somewhat closely related to this species. The Morrow form is distinguished from the earlier one by the generally more robust branches and the more closely spaced apertures as well as the tendency toward an arrangement of the zooecia in oblique series.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Cystodictya morrowensis n. sp.

Plate VII, figures 5-6a.

Description. Zoarium consisting of nearly rigid, bifoliate branches; the primary ones varying in width from 1.3 to 1.6 mm. and giving off, by bifurcation or more commonly by lateral division at intervals of 3 to 8 mm., secondary stipes, 0.8 to 1.2 mm. wide. In cross-section the branches are regularly elongate elliptical in outline, the narrower ones somewhat more strongly curved than the broader ones. Zooecia arranged in longitudinal series, separated by narrow, rounded ridges, indistinct on the best preserved specimens but more strongly elevated on the worn surfaces, with 5 or 6 ranges on the broader branches and 4 or 5 on the narrower and secondary ones; a definite oblique arrangement is also commonly present. Apertures small, oblique, 10 or 11 in 5 mm. longitudinally, peristome strongly elevated, crescentic on some specimens but normally complete; non-poriferous margins narrow but distinct.

Remarks. This species is comparable to but one other Pennsylvanian form, *C. lophodes,* from which it may be distinguished by its more elliptical cross-section, generally more numerous longitudinal series, and the closer spacing of the apertures.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

Genus COSCINIUM Keyserling

Coscinium fayettevillensis n. sp.

Plate VII, figure 3.

Description. Zoarium composed of bifoliate, inosculating branches attached at the base to some foreign object and united above into a fenestrated network. Branches 3.0 to 4.6 mm. in width and about 1 mm. thick; fenestrules elongate oval or somewhat irregular in outline, 1.5 by 2.7 mm. in diameter. Zooecia arranged in regular, longitudinal, curving rows without definite oblique series, 8 or 9 ranges on each branch; the portion adjacent to the fenestrules not occupied by zooecia, the non-poriferous area being wider in the line of the greater diameter of the fenestrules than along its lateral margins. Apertures sub-circular in outline, directed obliquely upward, peristome not strongly elevated, lunarium not preserved in the material at hand; 10 or 11

apertures in a 5 mm. space along the ranges, interspaces equal to about 1½ the diameter of the apertures but between apertures in adjacent rows the interspace is usually less than a diameter.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Choteau, Oklahoma (Station 302).

Coscinium gracilens n. sp.

Plate VII, figure 4.

Description. Zoarium a bifoliate expansion pierced by oval or circular fenestrules regularly arranged in quincunx. Spaces between the fenestrules comparatively small, the openings being separated by distances of about 2.5 mm. while the fenestrules average 2.1 mm. in diameter, varying from elongate oval in shape with dimensions of 2.3 by 1.6 mm., to circular in shape with diameters of 2.0 to 2.2 mm. Zooecia irregularly scattered over the surfaces of the fronds with a narrow non-poriferous strip around each fenestrule; an indefinite suggestion of a linear arrangement of the apertures may be observed in some portions of the frond with five or six of the irregular rows occurring between each two adjacent fenestrules. The apertures are not well preserved in the material at hand but they seem to have had an unequally elevated peristome and a lunarium directed away from the nearest fenestrule; apertures average 0.1 mm. in diameter and are separated by interspaces of more than their diameters.

Remarks. This species is apparently less abundant than the foregoing one in the Morrow formations and is characterized by the very slender inosculating branches which make up the frond and by the small number of zooecial ranges present in those parts of the zoarium where a linear development of the apertures is noticeable.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 134). Morrow formation: near Choteau, Oklahoma (Station 302).

Genus PRISMOPORA Hall

Prismopora concava n. sp.

Plate VII, figures 7, 7a.

Description. Zoarium consisting of triangular branching stems, the faces of which are sub-equal in width and transversely concave. The width of the faces varies between 3.5 and 4.0 mm. and the margins are very slightly sinuous and essentially parallel. Zooecia occupy the middle portion of each face over a space about 1 mm. in width and extend in a pinnate arrangement from this central strip to the lateral margins of the zoarium, leaving crescentic maculae curving inward from the margins. Between the non-poriferous and slightly depressed maculae, about 5 of which occur in 1 cm., there are 4 or 5 curving ranges of apertures with 5 or 6 zooecia in 2 mm. along the rows. Apertures circular, 1.5 to 2 diameters apart, directed obliquely to the face of the stem; peristomes faint and incomplete.

Remarks. The pinnate arrangement of the zooecia of this species suggests that of *Phractopora trifolia* of the Keokuk stage, but the generally smaller dimensions and structures of the zoarium make it evident that the material at hand represents the genus *Prismopora.* From *P. triangulata,* the common Pennsylvanian species, it is sharply distinguished by the orderly arrangement of the apertures and from *P. sereata* by its nearly straight margins.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Genus GLYPTOPORA Ulrich

Glyptopora crassistoma n. sp.

Plate VII, figures 2, 2a.

Description. Zoarium consisting of thin bifoliate expansions known only from fragments, the largest of which is 16 by 12 mm. in size. Surface marked by numerous lanceolate non-poriferous maculae or dimples irregularly placed but with a suggestion of a pinnate arrangement; dimples variable in size but ordinarily between 4 and 6 mm. in length and about 1 mm. in greatest width, depressed somewhat below the surface of the frond, adjacent ones about 3 mm. apart, measuring between

their middle points. Zooecia roughly arranged in diagonally intersecting series with 10 or 11 apertures in 5 mm.; apertures small but surrounded by thick and strongly elevated peristomes with walls approximately as thick as half the diameter of the apertures; apertures sub-oval or sub-circular in outline, normally about 0.2 mm. in diameter. Surface of frond between the apertures and within the dimples very finely rugose.

Remarks. Among the previously described representatives of this genus, all of which are reported from Mississippian strata, the material in hand is most nearly related to *G. keyserlingi* and *G. elegans.* It is clearly distinguished from those forms by the thick-walled and strongly elevated peristomes and the wider spacing of the zooecial apertures as well as by the absence of the peripheral ridges surrounding, more or less completely, the dimples of the zoaria referable to those species.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Ft. Gibson, Oklahoma (Stations 296 and 301).

BRACHIOPODA

DISCINIDÆ

Genus ORBICULOIDEA D'Orbigny

Orbiculoidea minuta n. sp.

Plate VIII, figures 2, 2a.

Description. Shell very small, sub-circular in outline. Dimensions of the type, a brachial valve: length, 3.3 mm.; width, 3.4 mm.; convexity, about 0.6 mm.

Pedicle valve nearly flat, pedicle opening excentric, external surface marked by regular concentric lines of growth.

Brachial valve depressed conical, the apex situated at about one-fourth the diameter of the shell from the posterior margin, the surface sloping with little or no curvature from apex to posterior margin, but distinctly, though slightly, concave from apex to anterior margin. Surface marked by fine, rounded, somewhat irregular, concentric lines of growth which are a very little elevated above the surface.

Remarks. This species is characterized by its small size and the concave anterior slope of the brachial valve, a character

which is probably persistent as it occurs in each of the two apparently undistorted specimens of that valve which have been observed.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Station 134).

Orbiculoidea missouriensis (Shumard) ?

Plate VIII, figure 1.

1858. *Discina missouriensis.* Shumard, Trans. St. Louis Acad. Sci., vol. 1, p. 221.
Middle Coal Measures: Lexington and Charbonnier, Missouri.

1873. *Discina nitida ?* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 572, pl. 25, fig. 1.
Coal Measures: Illinois.

1882. *Discina Meekana.* Whitfield, Ann, N. Y. Acad. Sci., vol. 2, p. 228.
Coal Measures: Carbon Hill and Flint Ridge, Ohio; Illinois; Iowa.

1884. *Discina nitida.* White, 13th Rep. Geol. Surv. Ind., p. 121, pl. 25, fig. 10.
Coal Measures: Indiana; Illinois; Iowa; Missouri; abundant at Cannelton and Horse Shoe of Little Vermilion.

1887. *Discina Meekana.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, pl. 2, figs. 8, 9.
Coal Measures: Flint Ridge, Ohio.

1887. *Discina nitida.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 145, pl. 2, figs. 8, 9.
Coal Measures: Flint Ridge, Ohio.

1888. *Discina nitida.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 226.
Lower Coal Measures: Des Moines, Iowa.

1891. *Discina Meekana.* Whitfield, Ann, N. Y. Acad. Sci., vol. 5, p. 598, pl. 15, figs. 1-3; also p. 603.
Coal Measures: Carbon Hill and Flint Ridge, Ohio.

1892. *Orbiculoidea nitida.* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 5, fig. 16.
Lower Coal Measures: Springfield, Illinois.

1892. *Orbiculoidea nitida.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 4F, figs. 23-29.
Coal Measures: Springfield, Illinois; Grover, Missouri.

1894. *Discina nitida.* Keyes, Mo. Geol. Surv., vol. 5, p. 39, pl. 35, fig. 6.
Coal Measures: Clinton, Lexington, and Richmond, Missouri.

1895. *Discina Meekana.* Whitfield, Geol. Surv. Ohio, vol. 7, p. 483, pl. 11, figs. 1-3; also p. 488.
Coal Measures: Carbon Hill and Hocking County, Ohio.

1900. *Orbiculoidea missouriensis.* Beede, Univ. Geo. Surv. Kans., vol. 6, p. 55, pl. 8, figs. 1-1c.
Upper and Lower Coal Measures: Fort Scott; Rosedale, Wyandotte County; Lansing, Leavenworth County; and Topeka, Kansas.

1910. *Lingulidiscina missouriensis.* Girty, Bull. U. S. Geol. Surv., No. 436, p. 22, pl. 1, figs. 6-10.
Phosphate beds, Park City formation: Woodruff Creek, Utah; Crawford Mountains, Sublette Range, and Thomas Fork, Wyoming; Montpelier, Idaho.

1911. *Orbiculoidea missouriensis.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 308, pl. 8, fig. 3.
Mercer limestone: Cannel Coal Mine, Flint Ridge, Ohio.

A single specimen of an *Orbiculoidea,* somewhat crushed, is referred provisionally to Shumard's species. The diameter of the shell, a brachial valve, is not greater than 8 mm. and the apex is, if any different, slightly more centrally located than in the typical representatives of the species, and the posterior and anterior slopes more nearly equal. It would not be practicable, however, to distinguish specifically the material at hand.

Horizon and locality. Brentwood limestone: Sawney Hollow, Oklahoma (Station 210).

RHIPIDOMELLIDÆ

Genus RHIPIDOMELLA Oehlert

Rhipidomella altirostris n. sp.

Plate VIII, figure 5-5c.

Description. Shell below medium size, sub-pentagonal in outline, length and breadth sub-equal, the hinge-line about half as long as the greatest width, the latter occurring half way between the anterior margin and mid-length of the shell. The dimensions of the holotype, a pedicle valve, are: length, 16 mm.; width, 17 mm.; length of hinge-line, 8.3 mm.; height of cardinal area, 4 mm.; convexity of pedicle valve, about 6 mm.

Pedicle valve convex, the greatest convexity posterior to the middle, the surface sloping from the umbonal region very abruptly toward the cardinal extremities, toward the anterior and anterio-lateral margins the surface curving very gently at first, but very strongly near the margins; beak broad, projecting very slightly beyond the cardinal area, incurved; cardinal area about half as high as wide, triangular, horizontally striated, sharply defined from the umbonal slopes, cardinal angles obtuse,

delthyrium about twice as high as wide, occupying the middle fourth of the area; mesial sinus originating in front of the umbo as a broad, shallow, rounded, undefined depression which becomes more conspicuous near the anterior margin; surface apparently devoid of radiate markings, although this may be due to the preservation of the available material, concentric growth lines conspicuous especially near the anterior and lateral margins of the valve. Hinge teeth large, deflected outward from the hinge-line at the base of the cardinal area.

Brachial valve and internal characters unknown.

Remarks. This species, based upon a single pedicle valve, is characterized by the strong elevation of the cardinal area. It is referred to *Rhipidomella* with considerable confidence in the absence of information concerning the muscular scars because of the general outline and appearance of the valve and the presence of the pair of large hinge-teeth.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 139).

Rhipidomella pecosi (Marcou)

Plate VIII, figures 3, 3a.

1858. *Orthis pecosii.* Marcou, Geol. N. A., p. 48, pl. 6, figs. 14-14b.
Mountain limestone: Pecos Village, New Mexico.

1858. *Orthis carbonaria.* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 218.
Middle Coal Measures: Lexington, Missouri.

1864. *Orthis* (sp. undet.) Meek, Pal. Cal., vol. 1, p. 10, pl. 2, figs. 5-5c.
Carboniferous: Bass's Ranch, Shasta County, California.

1872. *Orthis carbonaria.* Meek, U. S. Geol. Surv. Nebr., p. 173, pl. 1, figs. 8a-c.
Upper Coal Measures: Rock Bluff and Nebraska City, Nebraska; Iowa; Kansas; Illinois.
Middle Coal Measures: Lexington, Missouri.

1873. *Orthis carbonaria.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 571, pl. 25, fig. 4.
Upper Coal Measures: LaSalle, Illinois.

1877. *Orthis Pecosii.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 125, pl. 9, figs. 5a-c.
Carboniferous: Santa Fe, New Mexico.

1883. *Orthis carbonaria.* Hall, 2nd Rep. N. Y. State Geol., for 1882, pl. (7) 37, figs. 1-4.
Coal Measures: Springfield, Illinois.

1884. *Orthis Pecosi.* White, 13th Rep. Geol. Surv. Ind., p. 129, pl. 32, figs. 20-22.
Coal Measures: Horse Shoe of Little Vermilion and Garrett's Mill, Vermilion County, Indiana.
1892. *Orthis Pecosi.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 7, figs. 1-4.
Coal Measures: Near Springfield, Illinois.
1894. *Orthis pecosii.* Keyes, Mo. Geol. Surv., vol. 5, p. 64.
Coal Measures: Kansas City, Missouri.
1897. *Orthis pecosii.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 27.
Upper Coal Measures: Poteau Mountain, Indian Territory.
1900. *Rhipidomella pecosi.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 90.
Upper and Lower Coal Measures: Fort Scott, Kansas City, Eudora, Lawrence, and Lecompton, Kansas.
1903. *Rhipidomella pecosi.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 344.
Grand River region, Glenwood Springs, Colorado.
Base of Weber formation: Leadville district, Colorado.
Molas formation: San Juan region, Colorado.

This is a comparatively rare brachiopod in the Morrow fauna as it has been recognized at only three localities and is represented by only four specimens. Two are rather small and immature individuals while the other two are adults of the normal size. The form and markings are typical of the species.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 153); Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Genus SCHIZOPHORIA King

Schizophoria resupinoides (Cox)

Plate VIII, figures 6-8.

1857. *Orthis resupinoides.* Cox, Geol. Surv. Ky., vol. 3, p. 570, pl. 9, figs. 1-1b.
Coal Measures: Hawesville, Hancock County, Kentucky.
1881. *Orthis resupinoides?* White, U. S. Geog. Surv. west of 100th Merid., vol. 3, Supp., Appendix, p. xxiii, pl. 3, figs. 2a, b.
Carboniferous: Manuelites Creek, New Mexico.
1890. *Orthis resupinoides.* Worthen, Geol. Surv. Ill., vol. 8, p. 106, pl. 11, figs. 4a, b.
Lower Coal Measures: Mercer County, Illinois.
1897. *Orthis* cf. *resupinoides.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 28.
Lower Coal Measures: White and Conway Counties, Arkansas.

One of the most common forms in all the horizons of the Morrow group is a *Schizophoria* undoubtedly conspecific with that figured and described by Cox. The collections include shells of all sizes from those with a length of less than 10 mm. to those more than 35 mm. long. Although there is considerable variation in outline, convexity, and strength of the sinus, it does not seem practicable to attempt either a varietal or specific separation.

In comparison with *S. resupinata* (Martin) of Great Britain and Europe, the American form seems to be more strongly convex and with more nearly equal length and width. Authentic specimens of the European species are conspicuously broader transversely.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 139, and 149). Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood (Station 144) and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow formation: near Choteau (Stations 295, 302, and 306), Hulbert (Station 299), Ft. Gibson (Stations 301 and 303), and Gore (Station 304), Oklahoma.

STROPHOMENIDÆ

Genus ORTHOTETES Fischer

Orthotetes robusta (Hall)

Plate IX, figures 2-3a.

1858. *Orthis robusta.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 713, pl. 28, figs. 5a-d.
Lower Coal Measures: St. Clair County, Illinois.

1883. *Streptorhynchus robustus.* Hall, 2nd Rep. N. Y. State Geol., for 1882, pl. (10) 40, figs. 12-16.
Coal Measures: Illinois.

1892. *Derbya robusta.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 10, figs. 12-17.
Coal Measures: St. Clair County, Illinois.

1892. *Derbya robusta* (?). Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 11B, figs. 7, 8.
Upper Coal Measures: Winterset, Iowa; near Kansas City, Missouri.

1910. *Derbya robusta.* Raymond, Ann. Carnegie Mus., vol. 7, p. 158, pl. 27, fig. 8.
Ames limestone: Glenwood, Pennsylvania.

1911. *Derbya robusta.* Raymond, Penn. Topog. and Geol. Surv. Comm., Rep. for 1908-10, pl. 6, fig. 8.
Ames limestone: Glenwood, Pennsylvania.

Two pedicle valves and a number of brachial valves of this species are in the Morrow collections. They vary in length from less than 15 mm. to more than 45 mm. and display varying convexities depending upon the age of the individual. The surface markings when well preserved consist of radiating striae crossed by concentric growth lines, the latter more closely spaced and much finer than the former. One of the pedicle valves shows the high cardinal area, the vertically elongated delthyrium closed by the convex deltidium, and the median septum typical of the species.

Horizon and locality. Hale formation: East Mountain, Fayville, Arkansas (Stations 136, 137, and 149); Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 134, 135, and 153). Kessler limestone: near Brentwood (Station 144), and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow formation: near Choteau, Oklahoma (Station 306).

Orthotetes? sp.

Plate IX, figure 8.

A number of brachial valves of a strophomenoid brachiopod from the Brentwood limestone represents a form that is probably an undescribed species of *Orthotetes.* The shell is large, transversely elongated, with the hinge-line greater than any other diameter; it is rendered distinctly bilobate by an undefined rounded mesial sinus. The surface ornamentations consist of bifurcating, radiating striae crossed by fine concentric lines of growth. A nearly perfect example has a width along the hinge-line of 46 mm. and a length of 21 mm. In the absence of the pedicle valve it is impossible to identify the form generically with any degree of confidence.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135); Sawney Hollow, Oklahoma (Station 210).

Genus MEEKELLA White & St. John

Meekella striatocostata (Cox)

Plate X, figure 10.

1857. *Plicatula striato-costata.* Cox, Geol. Surv. Ky., vol. 3, p. 568, pl. 8, fig. 7.
Coal Measures: Providence, Hopkins County, Kentucky.

1858. *Orthisina Shumardiana.* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 183.
Lower Permian: Valley of Cottonwood, Kansas.

1858. *Orthisina missouriensis.* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 219.
Upper Coal Measures: Dallas, Missouri; Kansas.

1859. *Orthisina Shumardiana.* Meek and Hayden, Proc. Acad. Nat. Sci., Phil., p. 26.
Upper Coal Measures: Ft. Riley, Kansas.

1859. *Orthisina Missouriensis.* Meek and Hayden, Proc. Acad. Nat. Sci., Phil., p. 26.
Upper Coal Measures: Leavenworth, Kansas.

1859. *Streptorhynchus* (*Orthisina*) *Shumardianus.* Shumard, Trans. St. Louis Acad. Sci., vol. 1, p. 395.
Permian sandstone: Guadaloupe Mountains.

1863. *Orthisina occidentalis.* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 82.
Upper Coal Measures: Caldwell County, Missouri.

1866. *Orthis striato-costata.* Geinitz, Carb. und Dyas in Nebr., p. 48, tab. 3, figs. 22-24.
Crescent City, Iowa.

1868. *Meekella striato-costata.* White and St. John, Trans. Chicago Acad. Sci., vol. 1, p. 120, figs. 4-6.
Coal Measures: Iowa.

1872. *Meekella striato-costata.* Meek, U. S. Geol. Surv. Nebr., p. 175, pl. 5, figs. 12a-c.
Upper Coal Measures: Nebraska City, Bellevue, Plattsmouth, Otoe City, and Aspinwall, Nebraska; Kentucky; Iowa; Missouri; Illinois.

1877. *Meekella striatocostata.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 126, pl. 9, figs. 4a-e.
Carboniferous: Camp Cottonwood, Lincoln County, Nevada; Tenney's Ranch, Kaibab Plateau, Arizona; Kanab Canyon; Meadow Creek, south of Fillmore; Le Verkin's Creek, and at a cliff east of Belleview, Utah.

1883. *Streptorhynchus* (*Meekella*) *striatocostata.* Hall, 2nd Rep. N. Y. State Geol., for 1882, pl. (10) 40, figs. 18-23.

1884. *Meekella striatocostata.* White, 13th Rep. Geol. Surv. Ind., p. 130, pl. 26, figs. 12-14.
Coal Measures: Western part of Vigo County, Indiana.

1892. *Meekella striatocostata.* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 17, figs. 10-13.
Upper Coal Measures: Winterset, Iowa; Lawrence County, Kansas.

1892. *Meekella striatocostata.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 10, figs. 18-23; pl. 11B, figs. 20-22.
Upper Coal Measures: Winterset, Iowa; Lawrence County, Kansas.

1894. *Meekella striatocostata.* Keyes, Mo. Geol. Surv., vol. 5, p. 68, pl. 39, figs. 1a-e.
Upper Coal Measures: Kansas City, Missouri.

1900. *Meekella striatocostata.* Beede, Univ. Geol. Surv. Kans., vol. 5, p. 65, pl. 12, figs. 9-9c.
Upper and Lower Coal Measures: Fort Scott, Olathe, Kansas City, Eudora, Lawrence, Lecompton, Topeka, Beaumont, and Grand Summit, Kansas.

1903. *Meekella striatocostata.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 350.
Leadville district, Colorado.
Middle portion of Hermosa formation: San Juan region, Colorado.

1909. *Meekella striatocostata.* Girty, Bull. U. S. Geol. Surv., No. 389, p. 54, pl. 6, fig. 6.
Manzano group, Abo sandstone: Mesa del Yeso, and Abo Canyon, New Mexico.

This species is represented by a single incomplete specimen. The characteristic, striated, angular plications are, however, unmistakable. The shell is above the average size and is not so strongly curved transversely as many individuals which have been referred to the species, but the specific determination is made with considerable confidence.

Horizon and locality. Kessler limestone: near Brentwood, Arkansas (Station 144).

PRODUCTIDÆ

Genus CHONETES Fischer

Chonetes arkansanus n. sp.

Plate VIII, figure 4.

Description. Shell small, a little wider than long, hinge-line greater than any other width of shell, outline sub-semicircular. The dimensions of a typical right valve are: length, 3.3 mm.; width along hinge-line, 4.6 mm.; convexity, about 1.0 mm.

Pedicle valve rather strongly convex for shells of this genus, the greatest convexity occurring at the mid-length of the valve, the surface curving regularly from beak to anterior margin, the umbonal region strongly elevated above the somewhat flattened cardinal extremeties; cardinal angles slightly acute, hinge-line straight, lateral margin curving broadly into the regularly convex anterior margin; beak inconspicuous, projecting very slightly beyond hinge-line; mesial sinus obsolete.

Surface marked by comparatively coarse, radiating striae increasing by implantation or bifurcation, crossed by very fine concentric growth lines at irregular intervals. Shell structure finely punctate.

Remarks. The small size, comparatively coarse markings, and strongly elevated umbonal region which are characteristics of this species render it quite distinct from other species of the genus.

Horizon and locality. Brentwood limestone: Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Ft. Gibson (Station 303), and Gore (Station 304), Oklahoma.

Chonetes choteauensis n. sp.

Plate VIII, figures 9-10a.

Description. Shell below medium size, sub-semicircular in outline, valves very moderately convex, hinge-line equal to greatest width of valve anteriorly. The dimensions of a well-preserved pedicle valve are: length, 5.8 mm.; width, 9.7 mm.; convexity, about 2 mm.

Pedicle valve gently convex, the greatest curvature in front of the mid-length of the valve, umbonal region broad and poorly defined but elevated slightly above the cardinal extremities, the shell surface curved downward somewhat strongly near the anterio-lateral and anterior margins; cardinal extremities angular, the hinge-line meeting the lateral margins in approximately a right angle, lateral margins at first straight and parallel but rounding broadly into the anterior margin in front, anterior margin gently concave throughout its mesial portion; beak inconspicuous, not projected beyond hinge-line; mesial sinus broad, rounding, shallow and poorly defined, originating in the umbonal region and continuing, with increasing width and depth, to the anterior margin.

Surface of valve marked by fine, rounded, radiating striae which increase in number by bifurcation or implantation and are indiscernible when the shell is slightly worn. Very faint concentric lines of growth are occasionally present. Shell structure finely punctate.

Remarks. Kozlowski[44] has recently described a *Chonetes,* referring it to *C. glaber* Geinitz, from the Upper Carboniferous of Bolivia, which may prove to be conspecific with the shells described above. Judging from his excellent figures the two forms must be very closely related. Like the Morrow forms, those from Bolivia appear to be characterized by a moderately strong increase in convexity of the ventral valve near the anterior margin and the origination of the mesial sinus in the umbonal region at a distance from the beak. In typical *C. glaber,* as figured by Geinitz[45], the sinus originates on the beak of the ventral valve and is slightly sub-angular rather than shallowly rounded.

Horizon and locality. Morrow formation: near Choteau (Station 295), and Ft. Gibson (Station 301), Oklahoma.

Chonetes laevis Keyes

Plate VIII, figures 13, 14.

1888. *Chonetes laevis.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 229, pl. 12, figs. 3a-b.
Lower Coal Measures: Des Moines, Iowa.

1891. *Chonetes laevis.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 246.
Lower Coal Measures: Des Moines, Iowa.

1892. *Chonetes laevis.* Keyes, Proc. Iowa Acad. Sci., vol. 1, pt. 2, p. 22.
Lower Coal Measures: Near Des Moines, Iowa.

Keyes's description. "Shell small; much wider than long; transversely semi-elliptical; the cardinal line as long as the greatest width of the shell, or often slightly extended beyond the lateral margins. Ventral valve convex, with no indication of a mesial sinus; beak not prominent; cardinal area rather narrow but well defined centrally, becoming linear toward the extremities; foramen moderately wide; cardinal margin bearing from four to seven oblique spines on each side of the beak. Dorsal valve flat or very slightly concave with no mesial fold. Surface of both valves apparently perfectly smooth; but under a magnifier it is seen to be marked by numerous fine concentric striae and more prominent, often somewhat imbricated, lines of

growth; these are sometimes crossed by fine, nearly obsolete, radiating striae. Length, 7 mm.; breadth, 12 mm."

Remarks. Three pedicle valves and one brachial valve of this species are in the Morrow collections. All four are nearly flat and there is no suggestion of fold or sinus.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Genus PRODUCTUS Sowerby

Productus morrowensis n. sp.

Plate X, figures 1-4a.

Description. Shell medium to large in size, a little wider than long, strongly and regularly arched from beak to anterior margin; hinge-line nearly or quite as long as greatest width of shell. The dimensions of the holotype and three other specimens are:

Length of hinge-line	28.0 mm.,	±28.0 mm.,	±24.0 mm.,	±14.5 mm.
Distance from hinge-line to anterior margin	20.6 mm.,	21.0 mm.,	17.8 mm.,	15.0 mm.
Distance from umbonal region to anterior margin	24.0 mm.,	27.5 mm.,	26.8 mm.,	18.3 mm.
Convexity of the pedicle valve	15 mm.,	14 mm.,	14 mm.,	11 mm.

The dimensions of the allotype[46] and two other brachial valves are:

Length of hinge-line	21 mm.,	23 mm.,	18 mm.
Length (perpendicular to hinge-line) of visceral portion of valve	12.2 mm.,	12.2 mm.,	11.0 mm.
Depth of concavity of valve	10 mm.,	6 mm.,	8 mm.

Pedicle valve gibbous, strongly convex but not geniculate, more or less produced anteriorly depending on age of individual but only moderately extended even in old age. Beak full and tumid but not notably extended. Ears gently arched transversely, of medium size, and with cardinal angles closely approximating 90°; separated from cardinal slopes by sharply defined sub-angular depressions. The convergence of the latter depends upon the rapidity with which the umbo enlarges anteriorly and varies somewhat in different individuals. The umbonal angle does not depart far, however, from 115°. In the umbonal region the surface is regularly convex transversely

above the ears but anteriorly the venter* is fairly sharply defined from the main flanks and the outline of the valve towards its margin is distinctly subquadrate as a result of the flattening of the venter and main flanks. A shallow, rounded, undefined, mesial sinus originates on the umbo a short distance from the beak and extends to the anterior margin; on the venter it neither expands nor deepens notably and it is in most cases a rather inconspicuous feature of the shell, in some individuals the sinus is practically absent while in others it is moderately deep, considerable variation in its width also occurring in different shells. Surface of entire valve with the exception of the cardinal extremities marked by fairly strong, rounded costae[48] crossed by concentric ribs in the visceral portion of the valve and not rarely modified by the bases of erect tubular spines scattered irregularly over the surface. The costae increase in number in the visceral region by bifurcation or implantation and on the venter they may in some instances coalesce, with a corresponding decrease in number and increase in size; the coalescence normally takes place at the base of a spine where two or three costae unite to form one stronger costa which continues from the spine toward the anterior margin. In the anterior part of the visceral portion of the valve the number of costae in a 10 mm. space is typically 17 or 18, but may be as few as 14 or as many as 21. The concentric ribs of the visceral region are bent inward and compressed toward the cardinal margin but may again be deflected outward in crossing the ears where they are less strong and more closely crowded than on the umbonal slopes; there are generally 10 or 12 ribs in the space of 10 mm. in the umbonal region. Spines may occur anywhere on the shell surface but there is always a double row of spine bases which originates in the depression between the cardinal slopes and the ears and curves forward in a line roughly parallel to the surface of the venter and occupies the median portion of the main flanks. In this double row the large hollow spines ordinarily alternate in position and are normally

*"The pedicle valves of the *Producti* are often very convex or globose. In such cases the lateral sloping surfaces anterior to the cardinal and umbonal slopes may be termed the main slopes or main flanks, while the portion lying between these main flanks and extending from the umbo to the anterior extremity may be called the venter."[47]

situated at intervals of about 1.4 mm. from center to center; towards the cardinal line the rows of spines are bordered by a faint irregular ridge which is parallel to them and bounds a non-costate area which includes the lowermost cardinal slopes and the posterior portion of the main flanks and extends across the ears to the cardinal extremities. This part of the valve, which is rarely preserved, is marked only by concentric ribs and lines of growth.

Brachial valve very gently concave or nearly plane throughout the visceral portion but strongly geniculated toward the anterior and lateral margins; hinge-line straight and long, beak not elevated, cardinal extremities somewhat auriculate. Surface markings the same as those of pedicle valve, with the concentric ribs limited to the gently concave visceral portion of the valve.

Remarks. This, the most frequently collected and most characteristic of all the Morrow fossils, is a form which although obviously closely related to *P. semireticulatus* is readily recognized by the peculiar arrangement of spines on the cardinal slopes and main flanks of the ventral valve. In view of the persistence of this character the variations in depth of sinus, curvature of valve, and outline and size of shell, which may be observed, assume a minor importance and an attempt to subdivide the group on any of those bases seems to be futile. All the specimens from the Kessler limestone are below the average size of the species and the form is not nearly so abundant in that formation as in the two lower fossiliferous horizons.

Horizon and locality. Hale formation: vicinity of Fayetteville, Arkansas (Stations 136 and 149). Brentwood limestone: vicinity of Fayetteville (Stations 135, 138, 140, 147, and 150), near Brentwood (Station 145), and near West Fork (Station 154), Arkansas; Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood (Station 144), and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow formation: near Tahlequah (Station 293), Ft. Gibson (Station 296), Choteau (Stations 297, 298, 302, 306, and 307), Hulbert (Station 299), and Gore (Station 305), Oklahoma.

Productus welleri n. sp.

Plate IX, figures 10-11a.

Description. Shell of medium size, sub-hemispherical in shape, transversely sub-quadrate in outline, wider than long, hinge-line longer than greatest width of valves in front. Dimensions of two pedicle valves, the type and one other, are: length from hinge-line to anterior margin, 14.7 mm. and 13.0 mm.; length from umbonal region to anterior margin, 16.9 mm. and 16.0 mm.; length of hinge-line, +24 mm. and +20 mm.; width of valve midway from hinge-line to anterior margin, 20.3 mm. and 19.2 mm.; convexity of valve, 10 mm. and 9 mm. Dimensions of three brachial valves, the allotype and two others, are: length from hinge-line to anterior margin, 15.5 mm., +20 mm., and 11.5 mm.; length of hinge-line, 26 mm., 37 mm., and 16 mm.; width of valve midway from hinge-line to anterior margin, 23 mm., 34 mm., and 15 mm.; convexity of valve, 5.5 mm., 10.0 mm., and 2.5 mm.

Pedicle valve strongly and regularly convex longitudinally, somewhat flattened above the visceral region and on the venter, and with steep umbonal slopes and main flanks; beak full and strongly incurved beyond the hinge-line, umbonal angle about 100°; cardinal extremities produced, cardinal angle acute; ears longitudinally convex, fairly well set apart from the cardinal slopes and main flanks by a sinus on either side of the vaulted visceral region; a faint, shallow mesial sinus commonly originates in the umbonal region and crosses the venter to the anterior margin, is normally an inconspicuous feature of the shell, and in some cases is absent. Surface of valve marked by numerous close-set, but ordinarily quite faint, radiating costae which display a tendency to become obsolete in old age, crossed in the umbonal region by moderately strong concentric ribs which are deflected outward upon the ears; faint concentric lines of growth are present in all stages and in old age become conspicuous undulations; a single row of prominent bases of comparatively large, erect spines, commonly eight in number, crosses each ear from umbo to lateral margin and forms an angle of about 15° with the cardinal line, other and smaller spine bases irregularly scattered over the surface of the valve.

Brachial valve concave, the visceral region somewhat flattened, curving abruptly downward to the steep slopes of the main flanks and venter; beak projecting very slightly beyond the straight hinge-line, umbonal region rather sharply demarked from the longitudinally concave ears by abrupt changes in the surface contour at the foot of the gentle umbonal slopes; a distinct fold separates the extremities of the auriculations from the main flanks; cardinal extremities produced, cardinal angles acute. Surface markings the same as in the ventral valve.

Remarks. P. welleri is the second most abundant of the Morrow Producti and is equally as characteristic of these horizons as is *P. morrowensis*. In general appearance it resembles the *semireticulati* but its costae are not nearly so pronounced as those that ordinarily characterize the members of that group. The tendency for the costae to become obsolete in old age is suggestive of the group which Dr. Thomas has designated as the genus *Buxtonia*. That genus, however, is likely to prove the least satisfactory of his four new ones as this tendency is displayed by many of the otherwise typical species of *Productus* in the strict sense.

The remarkably constant linear arrangement of the few large spines along the ears is a noteworthy characteristic of this form.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: vicinity of Fayetteville (Stations 134, 135, 140, 147, 150, 152, and 153), and Brentwood (Station 145), Arkansas; Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Wagoner (Station 294), Hulbert (Station 299), Ft. Gibson (Station 303), Gore (Station 304), and Choteau (Stations 306 and 307), Oklahoma.

Productus nanus Meek & Worthen

Plate VIII, figures 12-12b.

1860. *Productus nanus.* Meek and Worthen, Proc. Acad. Nat. Sci., Phil., p. 450.
Lower Coal Measures: Jefferson County, Iowa.

1866. *Productus nanus.* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 320, pl. 26, figs. 4a-d.
Lower Coal Measures: Jefferson County, Iowa.

1888. *Productus nanus.* Keyes, Proc. Nat. Sci., Phil., p. 227.
Lower Coal Measures: Des Moines, Iowa.

The 25 or 30 specimens which have been referred to this species, although including forms which are very evidently conspecific with the single individual upon which the species was based, display the minor variations which one may safely expect in any species of *Productus*. In general they are apt to be a little more strongly convex than the type from Iowa—the measurement of 0.25 inch for its convexity is too large—and the ears are usually well demarked from the umbonal slopes. A few of the individuals display a faint but distinct mesial sinus which originates at a distance from the beak and in some there is a conspicuous ring-like inflation close to the lateral and anterior margins as in *P. marginicinctus*. 7 or 8 costae occur in 5 mm. in the central portion of the venter; the "suddenness" with which the costae increase in number is over-emphasized in Meek and Worthen's description. The length of the hinge-line may be somewhat greater than the width of the valve anterior to the hinge-line and in none of the Morrow specimens is it less. Spine bases are about as numerous on the ears and umbonal slopes as on the venter. The dimensions of two specimens are: length from hinge-line to anterior margin, 8.5 mm. and 8.4 mm.; distance from umbonal region to anterior margin, 10.4 mm. and 10.7 mm.; length of hinge-line, 12.5 mm. and 11.2 mm.; convexity of pedicle valve, 6 mm. and 7 mm.; depth of visceral cavity between pedicle and brachial valves, 3.5 mm., unknown in second specimen.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 149). Morrow formation: near Ft. Gibson (Station 303), and Gore (Station 304), Oklahoma.

Productus cora d'Orbigny

1842. *Productus cora.* D'Orbigny, Voy. dans l'Amer. merid., t. III, pt. 4, p. 55, pl. 5, figs. 8-10.

1847. *Productus cora.* De Koninck, Mon. du Gen. Prod. et Chon., p. 50, pl. 4, figs. 4a, b; pl. 5, figs. 2a-d.
Carboniferous: Guernsey County, Flint Ridge, and Zanesville, Ohio; between New Harmony and Mt. Vernon, Indiana; Leavenworth, Indiana; Windsor, Nova Scotia; Bolivia, etc., South America.

1848. *Productus Martini.* Christy, Letters on Geol., pl. 5, figs. 6, 8, 9. Pinckneyville, Illinois.

1852. *Productus semireticulatus.* Hall, Stansb. Exped. Gt. Salt Lake, p. 411, pl. 3, figs. 3, 5a, b.
Carboniferous: Near Fort Laramie; and Flat Rock Point and other places in the neighborhood of Great Salt Lake, Utah.

1852. *Productus cora.* Owen, Geol. Rep. Wis., Iowa, and Minn., tab. 5, fig. 1.
Carboniferous: Missouri River, below mouth of Little Platte River.

1852. *Productus cora.* Roemer, Kreid. von Texas, p. 90.
Carboniferous: San Saba Valley, Texas.

1854. *Productus cora.* Marcy's Explor. Red River of La., p. 175.
Carboniferous: Washington and Crawford Counties, Arkansas.

1855. *Productus cora.* Norwood and Pratten, Jour. Acad. Nat. Sci., Phil., 2nd Ser., vol. 3, p. 6.
Mountain limestone: Chester, Rosiclare, and Warsaw, Illinois; near Richmond, Missouri; Carrsville, Kentucky.

1855. *Productus Prattenianus.* Norwood, Jour. Acad. Nat. Sci., Phil., 2nd Ser., vol. 3, p. 17, pl. 1, figs. 10a-d.
Coal Measures: Crossing of Big Nemahaw River, about 85 miles northwest of St. Joseph, Missouri.

1855. *Productus cora.* Salter, Belcher's "Last of the Arctic Voyages," p. 387, pl. 36, fig. 12.
Carboniferous: Top of Exmouth Island.

1858. *Productus cora.* Marcou, Geol. N. A., p. 45, pl. 6, figs. 4, 4a.
Mountain limestone: Tigeras Canyon of San Antonio; Pecos Village; summit of Sierra de Sandia, New Mexico.

1858. *Productus ovatus.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, fig. 1.
St. Louis limestone: Ottumwa and Keosauqua, Iowa; St. Louis, Missouri.

1859. *Productus Prattenianus.* Meek and Hayden, Proc. Acad. Nat. Sci., Phil., p. 26.
Coal Measures: Indian Creek and Leavenworth, Kansas.

1859. *Productus pileiformis.* McChesney, Desc. New Pal. Foss., p. 40.
Kaskaskia limestone: Chester, Illinois.

1860. *Productus laevicostus.* White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 230.
Burlington limestone: Burlington, Iowa.

1863. *Productus coraeformis.* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 94.
Archimedes limestone: Cooper County, Missouri.

1863. *Productus cora.* Davidson, Quart. Jour. Geol. Soc. London, vol. 19, p. 174, pl. 9, figs. 22, 23.
Lower Carboniferous limestone: Windsor, Horton Bluff, Shubenacadie, Gays River, Cape Breton, Pugwash, eastward of Cumber-

land, Lennox Passage, McKenzies Mill, at eastern extremity of Wallace Harbor, etc., Nova Scotia.

1866. *Productus Flemingi.* Geinitz, Carb. und Dyas in Nebr., p. 52, tab. 4, figs. 1-4.
Bellevue, Plattsmouth, and Nebraska City, Nebraska.

1866. *Productus Koninckianus ?* Geinitz, Carb. und Dyas in Nebr., p. 53, tab. 4, fig. 4.
Nebraska City, Nebraska.

1868. *Productus cora.* Dawson, Acad. Geol., p. 297, figs. 98a, b.
Carboniferous limestone: Windsor, Horton Bluff, Shubenacadie, Gays River, Minudie, Cape Breton, Pugwash, east coast of Cumberland, Lennox Passage, McKenzies Mill, Wallace Harbor, etc., Nova Scotia.

1872. *Productus Prattenianus.* Meek, U. S. Geol. Surv. Nebr., p. 163, pl. 2, figs. 5a-c; pl. 5, fig. 13; pl. 8, figs. 10a, b.
Upper Coal Measures: Nebraska City, Bennett's Mill, Cedar Bluff, Plattsmouth, Bellevue, and Omaha, Nebraska; Kansas; Iowa; Illinois.
Lower Coal Measures: Illinois.

1874. *Productus Prattenianus* (*? P. laevicostus*). White, Prelim. Rep. Inv. Foss., p. 17.
Subcarboniferous: Below Ophir City, Utah.

1874. *Productus cora* (*?*). Derby, Bull. Cornell Univ. (Sci.), vol. 1, No. 2, p. 49, pl. 2, fig. 17; pl. 6, fig. 17.
Coal Measures: Itaituba and Barreirinha, Brazil.

1876. *Productus Prattenianus.* White, Powell's Rep. Geol. Uinta Mts., p. 90.
Lower Aubrey group: Confluence of Grand and Green Rivers, Utah.

1877. *Productus Prattenianus.* Meek, U. S. Geol. Expl. 40th Par., vol. 4, p. 72, pl. 7, fig. 7.
Carboniferous: Fossil Hill, White Pine District; Railroad Canyon, Diamond Mountains, Nevada.

1877. *Productus Prattenianus.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 113, pl. 7, figs. 1a-c.
Carboniferous: Near Santa Fe and Zandia Mts., New Mexico; Piloncillo range near Gavilan Peak, and at the confluence of White Mountain and Black Rivers, Arizona; Egan Range, 35 miles south of Egan Pass; Fossil Hill, White Pine County; Robert's Creek Range, Lander County; and top of Grass Mountain, Ely Range, 35 miles north of Pioche, Nevada; near Beckwith Spring, Cedar Range; near top of Mount Nebo, and west face of Oquirrh Range, Utah.
Subcarboniferous: Mountain Spring, Lincoln County, Nevada, and below Ophir City, Utah.

1877. *Productus laevicostus ?.* Hall and Whitfield, U. S. Geol. Expl. 40th Par., vol. 4, p. 266, pl. 5, figs. 7, 8.

Lower Carboniferous limestone: North of Snowstorm Hill, Dry Canyon, Oquirrh Mountains, Utah.

1883. *Productus ovatus.* Hall, 2nd Ann. Rep. N. Y. State Geol., for 1882, pl. (18) 49, fig. 19.
Keokuk limestone: New Providence, Indiana.

1884. *Productus Cora.* White, 13th Rep. Geol. Surv. Ind., p. 126, pl. 26, figs. 1-3.
Coal Measures: Fountain, Vermilion, Parke, Montgomery, Clay, Owen, Pike, Dubois, and Warrick Counties, Indiana.

1886. *Productus Cora.* Heilprin, 2nd Geol. Surv. Penn., Ann. Rep. 1885, p. 452; p. 440, figs. 1, 1a.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1886. *Productus Cora.* Heilprin, Proc. and Coll. Wyo. Hist. and Geol. Soc., vol. 2, pt. 2, p. 268, figs. 1, 1a.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1887. *Productus Cora.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 47, pl. 2, fig. 26.
Coal Measures: Flint Ridge, Ohio.

1888. *Productus cora.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 227.
Lower Coal Measures: Des Moines, Iowa.

1891. *Productus pileiformis.* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 582, pl. 13, figs. 13, 14.
Maxville limestone: Ohio.

1892. *Productus sp? cf. Prattenianus.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, fig. 4.
Waverly sandstone: Newark, Ohio.

1892. *Productus ovatus.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 18, fig. 19.
Keokuk limestone: New Providence, Indiana.

1894. *Productus laevicostus.* Keyes, Mo. Geol. Surv., vol. 5, p. 41, pl. 38, fig. 1.
Kinderhook group: Louisiana, Missouri.
Burlington group: Louisiana, Missouri.

1894. *Productus ovatus.* Keyes, Mo. Geol. Surv., vol. 5, p. 44.
St. Louis limestone: St. Louis, Missouri.

1894. *Productus cora.* Keyes, Mo. Geol. Surv., vol. 5, p. 47, pl. 37, figs. 2a-c.
Coal Measures: Calhoun and Kansas City, Missouri.

1895. *Productus pileiformis.* Whitfield, Geol. Surv. Ohio, vol. 7, p. 470, pl. 9, figs. 13, 14.
Maxville limestone: Ohio.

1897. *Productus cora.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 28.
Upper Coal Measures: Poteau Mountains, Indian Territory.
Archimedes limestone: Independence County, Arkansas.

Marshall shale: Independence and Stone Counties, Arkansas.
Fayetteville shale: Independence County, Arkansas.

1899. *Productus laevicostus.* Girty, Mon., U. S. Geol. Surv., No. 32. p. 534, pl. 69, figs. 9a-c.
Madison limestone: Many localities, Yellowstone National Park.

1900. *Productus cora.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 75, pl. 11, figs. 1-1f.
Upper Coal Measures: Kansas City, Eudora, Lawrence, Lecompton, Topeka, Grary County, Melvern, Osage County, Kansas.

1900. *Productus laevicostus.* Weller, Trans. St. Louis Acad. Sci., vol. 10, p. 71, pl: 1, figs. 1, 2.
Chonopectus sandstone: Burlington, Iowa.

1903. *Productus laevicosta.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 284.
Ouray limestone: San Juan region, Colorado.

1903. *Productus cora.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 364, pl. 4, figs. 1-4b.
Hermosa formation: San Juan region; Ouray, Colorado.
Rico formation: San Juan region, Colorado.
Weber limestone and Maroon formation: Crested Butte District; Leadville District, Colorado.

1903. *Productus cora.* Paleontologia Universalis, Fasc. 1, 2.

1909. *Productus pileiformis.* Girty, Bull., U. S. Geol. Surv., No. 377, p. 26, pl. 2, fig. 7.
Caney shale: McAlester quadrangle, Oklahoma.

1909. *Productus cora.* Girty, Bull., U. S. Geol. Surv., No. 389, p. 58.
Manzano group, Abo sandstone: Mesa del Yeso, Abo Canyon, and Sandia Mountains, New Mexico.

1911. *Productus pileiformis.* Girty, Bull., U. S. Geol. Surv., No. 439, p. 44, pl. 4, figs. 1, 2.
Moorefield shale: Spring Creek, Batesville quadrangle, and Marshall, Marshall quadrangle, Arkansas.

1911. *Productus pileiformis.* Morse, Proc. Ohio State Acad. Sci., vol. 5, p. 370, figs. 8a-c.
Maxville limestone, Upper Zone: Mouth of Buckeye Fork, Fultonham; Gladstone Mills, Thompson Residence, below Thompson Residence, White Cottage, Ohio.
Lower Zone: Cut No. 4, Mount Perry, Fultonham, Fold Quarry, Rushville, Ohio.

1911. *Productus laevicostus.* Beede, N. Y. State Museum, Bull. No. 149, p. 163.
Mississippian: Magdalen Islands, Quebec, Cape le Trou, Grindstone Island.

1912. *Productus cora.* Boutwell, Prof. Paper, U. S. Geol. Surv., No. 77, p. 48, pl. 6, figs. 1-2a.
Limestone in Weber quartzite: Near Park City district, Utah.

1914. *Productus ovatus.* Weller, Ill. State Geol. Surv., Mon. I, p. 132, pl. 16, figs. 1-15.
Chonopectus sandstone: Burlington, Iowa.
Kinderhook, Bed No. 7: Burlington, Iowa.
Lower Burlington limestone: Near Springfield, Missouri.
Keokuk limestone: Near Springfield, Missouri.
St. Louis limestone: St. Louis, Missouri.
Chester group: Chester, Illinois; Meade County, Kentucky.

This species, one of the most common in all the Morrow horizons, displays considerable variation in size and some in shape. All the forms, however, agree in bearing fine, often flexuous striae which are somewhat finer near the beak than on the venter and main flanks. In the former location there are from 12 to 16 striae in 5 mm. while in the latter only 7 to 12 occur in the same space. The hinge-line is always shorter than the greatest width of the valve and bears small wrinkled ears which ordinarily are not preserved. Concentric wrinkles cross the valves in the visceral region, becoming fainter or even disappearing on the venter, but invariably prominent on the main flanks and cardinal slopes. The dimensions of three of the better preserved individuals are: length of hinge-line, 22 mm., ±15 mm., 10.5 mm.; greatest width, 38 mm., ±31 mm., ±12 mm.; distance from hinge-line to anterior margin, 28.5 mm., 23 mm., 10.2 mm.; length from anterior margin to umbonal region, 38 mm., 32.5 mm., ±14 mm.

The forms from the various Mississippian and Pennsylvanian horizons, which have been described under the names *P. cora*, *P. ovatus*, *P. pileiformis*, *P. laevicostus*, and *P. prattenianus*, are evidently the individuals of a single, closely related group. To attempt the designation of its mutations under separate specific or varietal names appears to be impracticable at present and may be unnecessary. It has been the custom in recent years to designate the Pennsylvanian members of the species as *P. cora* and the Mississippian ones as *P. ovatus*. The forms from the Morrow group, at least, are indistinguishable from the common Mississippian types and if any subdivision of the species can be consistently made they will have to be included with the Mississippian rather than with the Middle and Upper Pennsylvanian varieties. It is believed that the best course to pursue is to recognize that we have here a single long-lived species which ranged from the Kinderhook through the Upper Coal Measures.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 134, 135, ?148, 152, and 153); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood, Arkansas (Station 144). Morrow formation: near Ft. Gibson (Stations 296 and 303), Choteau (Stations 297, 298, and 302), Hulbert (Station 299), and Gore (Station 304), Oklahoma.

Productus gallatinensis Girty

Plate IX, figures 4-5b.

1899. *Productus gallatinensis.* Girty, Mon., U. S. Geol. Surv., No. 32, p. 533, pl. 68, figs. 7a-c, 11a-d.
Madison limestone: Yellowstone National Park.

1903. *Productus gallatinensis.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 361, pl. 3, figs. 4-8a.
Hermosa formation: San Juan region; Ouray, Colorado.
Crested Butte district, Colorado.

The fossils from the Morrow group referred to this species are apparently identical with the forms from the Hermosa limestone described and figured under this title. Their identity with the types from the Madison limestone is, however, not so clear. It is possible that the Pennsylvanian species is not the same as the Mississippian one and in that case it would seem likely that the forms from the upper horizons should be referred to *P. boonensis* Swallow.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136 and 137). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 138, 148, and ?153). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Wagoner (Station 294), Choteau (Station 298), and Gore (Station 304), Oklahoma.

Productus fayettevillensis n. sp.

Plate X, figures 5-6.

Description. Shell of medium size, transversely sub-oval in outline, wider than long, length of hinge-line a little less than greatest width of valve. Dimensions of the holotype, an average specimen, are: length from hinge-line to anterior margin, 16.1 mm.; distance from umbonal region to anterior margin,

17.3 mm.; greatest width of valve, 23.3 mm.; length of hinge-line, 20.0 mm.; convexity of pedicle valve, about 6.0 mm.

Pedicle valve with low convexity, not produced far beyond visceral region in any of the two-score specimens at hand; greatest convexity in the umbonal region posterior to the middle, the valve sloping rather abruptly toward the hinge-line and ears but quite gently toward the lateral and anterior margins; beak small and incurved close to hinge-line; umbonal region expanding rapidly, not projected far beyond hinge-line; umbonal angle about 130°; ears not sharply defined from umbonal slopes, cardinal angle approximating 90° or very slightly obtuse; venter flattened, rounding regularly into the main flanks on either side, modified by a shallow sinus which originates in the umbonal region and is normally inconspicuous though varying in depth and sharpness of definition. Surface of valve bearing numerous, close-set, but comparatively strong, radiating costae which originate on the umbo as very slender striae but increase regularly in width and strength toward the anterior and lateral margins without any very notable increase in number though bifurcation and interpolation of costae in some instances occurs; about 20 costae occupy a space of 5 mm. on the umbo and about 10 the same distance near the anterior margin of the venter; radiating costae are crossed by numerous concentric ribs which are about as strong on the venter as on the flanks although disappearing on the ears; about 5 ribs occupy the space of 5 mm. on the venter while toward the beak they are more closely spaced; there is a strong tendency for the costae to develop nodes at the intersections with the ribs; a few bases of erect tubular spines occur irregularly scattered over the surface of the valve and in the depressions which separate the ears from the cardinal slopes show a tendency to become arranged in two alternating linear series parallel to the anterior margins of the ears.

Brachial valve unknown.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville (Stations 134 and 150) and West Fork (Station 154), Arkansas; Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood (Station 144) and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow for-

mation: near Choteau (Stations 298, 302, and 307), Hulbert (Station 299), and Ft. Gibson (Station 303), Oklahoma.

Productus sp.

Plate VIII, figures 16-16b.

A single large *Productus* of the *P. cora* type, preserved as an internal cast of the pedicle valve, is included in the collections from the Kessler limestone. Although similar to *P. cora* it probably represents a distinct species. The outline is strongly transverse with the hinge-line nearly or quite as long as the greatest width of the valve; the ears are large and well-defined, the cardinal angles closely approximating 90°; the cardinal slopes are very steep, the main flanks somewhat less abrupt and the venter even more gently convex; the vault of the visceral cavity is distinctly flattened above, corresponding to the transverse flattening of the venter; a faint mesial sinus seems to originate in the umbonal region and crosses the venter, becoming obsolete before reaching the anterior margin, although it is possible that this feature is due to crushing of the apparently thin shell. Strong concentric wrinkles cross the cardinal slopes and main flanks from the ears but die out upon the venter; radiating costae are present everywhere on the surface of the shell, with the possible exception of the ears, with 17 or 18 to the centimeter near the margins; the bases of strong inclined spines are present on the ears where they have a distinctly linear arrangement and spine bases may be present elsewhere on the surface of the valve.

The dimensions of the specimen in hand are: length from hinge-line to anterior margin, 36 mm.; distance from umbonal region to anterior margin, 38.5 mm.; length of hinge-line, +55 mm.; convexity of pedicle valve, about 20 mm.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Genus PUSTULA Thomas

Pustula pertenuis (Meek)

Plate IX, figures 9-9a.

1866. *Productus Cancrini.* Geinitz, Carb, und Dyas in Nebr., p. 54, tab. 4, fig. 6. (Not *P. cancrini* DeKoninck.)
Nebraska City, Nebraska.

1872. *Productus pertenuis.* Meek, U. S. Geol. Surv. Nebr., p. 164, pl. 1, figs. 14a-c; pl. 8, figs. 9a-d.
Upper Coal Measures: Nebraska City and Brownsville, Nebraska; Grasshopper Creek, 12 miles west of Leavenworth and at Atchison, Kansas.

1898. *Productus pertenuis.* Drake, Proc. Am. Phil. Soc., vol. 36, p. 404, pl. 9, figs. 8-10.
Lower Coal Measures: 4 miles north of Vinita, and 1 mile south of Muscogee, Indian Territory.
Upper Coal Measures, Cavaniol group: McClellan Ford on Verdigris River, Indian Territory.
Poteau group: 6 miles west of South Canadian, Indian Territory.
Pawhuska sandstone: 5 miles west of Cushing, Indian Territory.
Boston group: 5 miles southeast of Adair, Indian Territory.

1900. *Productus pertenuis.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 83, pl. 9, figs. 5-5c.
Upper Coal Measures: Kansas City, Eudora, Lawrence, Lecompton, and Topeka, Kansas.

1903. *Productus pertenuis ?.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 367.
Middle portion of Hermosa formation: San Juan region, Colorado.

A number of shells in the Morrow collections appear to be conspecific with Meek's specimens. They are all small, the dimensions of two average individuals being: length from hinge-line to anterior margin, 5.9 mm., 6.4 mm.; distance from umbonal region to anterior margin, 7.2 mm., 7.4 mm.; length of hinge-line, 9.0 mm., 9.6 mm.; convexity of pedicle valve, —3.0 mm., —3.0 mm. The concentric ribs are more conspicuous than the radiating costae and the agreement with the figures and descriptions of the type is very close.

It is probable that Drake's figures, cited above, represent a form which should not be entered in the synonymy of this species. The specimen figured is not from the Morrow group, as might be inferred from the statement of its locality and horizon, as it is now known that the strata outcropping 5 miles southeast of Adair, Oklahoma, are a part of the Fayetteville shale.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Ft. Gibson (Stations 296 and 303), and Gore (Station 304), Oklahoma.

Pustula globosa n. sp.

Plate X, figures 7-9.

Description. Shell small, sub-globular in shape, usually a little wider than long, length of hinge-line less than the greatest width of valve. Dimensions of the type specimen are: greatest width, 8.1 mm.; length of hinge-line, 6.7 mm.; length from hinge-line to anterior margin, 7.6 mm.; convexity of pedicle valve, ±5.5 mm.; length from umbonal region to anterior margin, 9.0 mm.

Pedicle valve strongly and regularly convex longitudinally and transversely, sub-hemispherical in shape, the venter slightly flattened in old age; beak small and pointed, incurved over hinge-line; ears small and poorly defined, cardinal extremities rounded. Surface of valve non-costate, crossed by faint concentric lines of growth which near the margin in the older individuals become stronger and more conspicuous; a few bases of large erect spines scattered irregularly over the surface, about as numerous in the visceral portion of the valve as near the margins.

Brachial valve concave, the surface sloping rather abruptly from the umbonal region toward the ears which are more sharply defined than in the pedicle valve, somewhat flattened in the visceral region but deflected strongly downward toward the lateral and anterior margins; beak small and inconspicuous, umbonal region moderately well developed. Surface ornamentation similar to that of the pedicle valve with the concentric lines perhaps somewhat more conspicuous.

Remarks. This rather abundant form may be compared with *P. indianensis* (Hall) of the Salem limestone which it resembles in a general way. It differs from that species in its somewhat larger size and more spherical shape, its greater breadth through the visceral region and more nearly parallel main flanks. There seems to be no Pennsylvanian form with which it is comparable.

The reference to *Pustula* is made on account of the absence of costae and because it is "essentially spinose in ornamentation." It will probably be advantageous to separate such non-costate forms with comparatively large erect spines from the typical "pustulose" members of that genus and designate them by some other generic name. In this instance it is recognized that there is a possibility that this form may in reality be a *Productella*

as its general appearance is strongly suggestive of the species referred to that genus.

Horizon and locality. Brentwood limestone: Fayetteville, Arkansas (Station 148); Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Choteau (Station 299), and Ft. Gibson (Station 303), Oklahoma.

Pustula sublineata n. sp.

Plate IX, figures 1-1c.

Description. Shell productiform, a little below medium size, wider than long, subquadrate in outline, length of hinge-line equal to greatest width. Dimensions of the holotype and one other specimen are: length from hinge-line to anterior margin, 14.1 mm. and 16.5 mm.; length from umbonal region to anterior margin, 17.3 mm. and 20.4 mm.; length of hinge-line (width of shell), 19.0 mm. and 20.6 mm.; convexity of pedicle valve, 10 mm. and 12 mm.; depth of visceral cavity between the two valves, 6 mm. and 8 mm.

Pedicle valve strongly convex, the greatest convexity occurring posterior to the middle of the shell, the surface sloping very abruptly downward toward the hinge-line and quite gently toward the anterior margin; the main flanks sharply differentiated from the cardinal slopes which are almost at right angles to the flanks and separated from them by sudden deflections in the surface of the shell, curving less abruptly forward and upward along the line of union with the venter; the venter broad and flattened, its margins converging gently posteriorly and its surface passing imperceptibly into that of the visceral and umbonal regions; beak small, not projected far beyond hinge-line; umbonal region flattened on top but with moderately abrupt lateral slopes; ears not differentiated from the cardinal slopes, cardinal extremities sub-angular, lateral margins joining hinge-line at angle of approximately 90°; a shallow, rounded, ill-defined mesial sinus originating in the umbonal region at a little distance from the beak and continuing, without much increase in width or depth upon the venter, to the anterior margin.

Brachial valve flattened throughout visceral region but moderately strongly geniculated toward the anterior and lateral margins; beak inconspicuous, umbonal region slightly concave, ears

not distinct from visceral region; lateral margins meeting the hinge-line at right angles but curving gracefully into anterior margin.

Surface of both valves when well preserved marked by very fine, discontinuous costae which are seen in worn specimens to be due to the linear arrangement of small, somewhat prostrate spines thickly distributed over the surface of the valve, whose presence is known in the material at hand solely from the punctate scars marking the points of attachment. Concentric ribs cross the umbonal region of both valves at irregular intervals while toward the anterior margin the concentric growth lines which mark the surface become quite conspicuous and somewhat undulatory.

Remarks. It is evident that this form belongs to the group of shells typified by *P. longispina* (Sowerby) but its distinctive characters are so striking as to warrant the erection of a new species to receive it. Most notable, probably, are the absence of definite auriculations in either valve and the fairly sharp boundary between the cardinal slopes and main flanks due to the posterior deflection of the former.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 152).

Pustula nebraskensis (Owen)

Plate IX, figures 6, 7.

1852. *Productus nebrascensis.* Owen, Geol. Rep. Wis., Iowa, and Minn., p. 594, tab. 5, fig. 3.
Carboniferous limestone: Bellevue, Missouri River, Nebraska.

1855. *Productus Rogersi.* Norwood and Pratten, Jour. Acad. Nat. Sci., Phil., 2nd ser., vol. 3, p. 9, pl. 1, figs. 3a-c.
Coal Measures: Near Huntsville, Missouri.

1855. *Productus nebrascensis.* Norwood and Pratten, Jour. Acad. Nat. Sci., Phil., 2nd ser., vol. 3, p. 21.
Coal Measures: Crossing of Big Nemahaw, Nebraska Territory.

1856. *Productus rogersi.* Hall, Pac. R. R. Rep., vol. 3, p. 104, pl. 2, figs. 14, 15.
Carboniferous limestone: Pecos Village, New Mexico.

1859. *Productus Rogersi.* Meek and Hayden, Proc. Acad. Nat. Sci., Phil., p. 26.
Upper Coal Measures: Kansas River Valley, below mouth of Blue River, Kansas.

1860. *Productus asperus.* McChesney, Desc. New Pal. Foss., p. 34.
Coal Measures: LaSalle and Springfield, Illinois.

1861. *Productus Rogersi.* Newberry, Ives's Colo. Expl. Exped., p. 121.
Coal Measures: Pecos Village and Kansas.

1865. *Productus asper.* McChesney, Ill. New Spec. Foss., pl. 1, figs. 7a-b.

1866. *Strophalosia herrescens.* Geinitz, Carb. und Dyas in Nebr., p. 49.
Bellevue, Plattsmouth, Nebraska City, and Bennett's Mill, Nebraska.

1868. *Productus nebrascensis.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 24, pl. 1, figs. 7a, b.
Coal Measures: LaSalle and Springfield, Illinois.

1872. *Productus Nebrascensis.* Meek, U. S. Geol. Surv. Nebr., p. 165, pl. 2, fig. 2; pl. 4, fig. 6; pl. 5, figs. 11a-c.
Upper Coal Measures: Nebraska City, Wyoming, Bennett's Mill, Rock Bluff, Plattsmouth, Bellevue, and Omaha, Nebraska.
Coal Measures: Illinois; Missouri; Iowa; Kansas; New Mexico.

1873. *Productus Nebrascensis.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 569, pl. 25, fig. 8.
Coal Measures: Sangamon and LaSalle Counties, Illinois.

1876. *Productus Nebrascensis.* White, Powell's Rep. Geol. Uinta Mts., p. 90.
Lower Aubrey group: Confluence of Grand and Green Rivers.

1877. *Productus Nebrascensis.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 116, pl. 8, figs. 3a-d.
Carboniferous: Camp Apache and Carrizo Creek, Maricopa County, Arizona; Rubyville, Schell Creek range, and top of Grass Mountain, Ely Range, Nevada; Meadow Creek, south of Fillmore, Utah.

1883. *Productus asperus.* Hall, Rep. N. Y. State Geol., for 1882, pl. (19) 50, figs. 5-7.
Coal Measures: LaSalle, Illinois.

1884. *Productus Nebrascensis.* White, 13th Rep. Geol. Surv. Ind., p. 122, pl. 24, figs. 7-9.
Coal Measures: Fountain, Vermilion, Parke, and Vigo Counties, Indiana.

1886. *Productus Nebrascensis ?.* Heilprin, 2nd Geol. Surv. Penn., Ann. Rep. for 1885, p. 453, fig. 4c; p. 440, figs. 4-4b.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1886. *Productus Nebrascensis ?.* Heilprin, Proc. and Coll. Wyo. Hist. and Geol. Soc., vol. 2, pt. 2, p. 268, figs. 4, 4b.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1887. *Productus Nebrascensis.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 49, pl. 2, fig. 30.
Coal Measures: Flint Ridge, Ohio.

1888. *Productus Nebrascensis* (?). Herrick, Bull. Sci. Lab. Den. Univ., vol. 3, p. 31, pl. 1, fig. 24; pl. 3, figs. 25 (?), 25a.
Waverly group: Licking County, Ohio.

1892. *Productus Nebrascensis.* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 22, fig. 7.
Coal Measures: LaSalle, Illinois.

1892. *Productus Nebrascensis.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 19, figs. 5-7.
Coal Measures: LaSalle, Illinois.

1894. *Productus nebrascensis.* Keyes, Mo. Geol. Surv., vol. 5, p. 48, pl. 37, figs. 3a-c.
Upper Coal Measures: Kansas City, Missouri.

1900. *Productus nebrascensis.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 84, pl. 9, figs. 7-7f.
Upper Coal Measures: Kansas City, Turner, Eudora, Lawrence, Lecompton, Topeka, Manhattan, and Grand Summit, Kansas.

1903. *Productus nebraskensis.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 370, pl. 5, figs. 1-2a.
Hermosa formation: San Juan region; Ouray, Colorado.
Rico formation: San Juan region, Colorado.
Base of Weber formation: Leadville district, Colorado.

1904. *Productus nebraskensis.* Girty, Prof. Paper, U. S. Geol. Surv., No. 21, p. 53, pl. 11, figs. 7-9.
Coal Measures: Nebraska.
Naco limestone: Bisbee quadrangle, Arizona.

1909. *Productus nebraskensis.* Girty, Bull., U. S. Geol. Surv., No. 389, p. 62, pl. 7, figs. 5, 6.
Manzano group, Abo sandstone: Abo Canyon, Mesa del Yeso, and Sandia Mountains; Yeso formation: Mesa del Yeso, New Mexico.

The Morrow collections include a number of specimens which fall within the limits of this species as ordinarily defined. In general, the material at hand displays a shorter hinge-line and more nearly parallel main flanks than characterize the typical Coal Measures type but it is not considered expedient to separate this form under a different name at present.

Horizon and locality. Brentwood limestone: Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood, Arkansas (Station 144). Morrow formation: near Wagoner (Station 294), Ft. Gibson (Stations ?296 and 303), Choteau (Stations 298 and 306), and Gore (Station 304), Oklahoma.

Pustula punctata (Martin)

Plate VIII, figure 11.

1836. *Productus punctatus ?.* Morton, Am. Jour. Sci., 1st ser., vol. 29, p. 153, pl. 26, fig. 38.
Coal Measures: Ohio Valley.

1838. *Productus semipunctata.* Shepard, Am. Jour. Sci., 1st ser., vol. 34, p. 153, fig. 9.
Limestone: Peru, Illinois.

1847. *Productus punctatus.* DeKoninck, Mon. du Gen. Prod. et Chon., p. 123, pl. 12, figs. 2a-k.
Carboniferous: Zanesville, Ohio; Eddyville and Louisville, Kentucky.

1854. *Productus punctatus.* Shumard, Marcy's Expl. Red. River of La., p. 175, pl. 1, fig. 5; pl. 2, fig. 1.
Carboniferous: Washington County, Arkansas.

1855. *Productus punctatus.* (Part). Norwood and Pratten, Jour. Acad. Nat. Sci., Phil., 2nd ser., vol. 3, p. 19.
Coal Measures: 12 miles northwest of Richmond, Missouri; near Caseyville, Illinois.

1858. *Productus punctatus.* Marcou, Geol. N. A., p. 48, pl. 6, fig. 2.
Mountain limestone: Tigeras, Pecos Village, and in the Sierra de Mogoyon, New Mexico.

1860. *Productus tubulospinus.* McChesney, Desc. New Pal. Foss., p. 37.
Coal Measures: Western States.

1865. *Productus tubulospinus.* McChesney, Ill. New Spec. Foss., pl. 1, figs. 10, 11.

1868. *Productus punctatus.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 27, pl. 1, figs. 10, 11.
Upper and Lower Coal Measures: Throughout the Western States.

1872. *Productus punctatus.* Meek, U. S. Geol. Surv. Nebr., p. 169, pl. 2, fig. 6; pl. 4, fig. 5.
Upper Coal Measures: Nebraska City, Bennett's Mill, Wyoming, Rock Bluff, Plattsmouth, and Bellevue, Nebraska; Illinois; Iowa; Missouri.
Lower Coal Measures: Missouri; Iowa; Illinois.
Lower Carboniferous: Missouri; Iowa; Illinois.

1873. *Productus Punctatus.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 569, pl. 25, fig. 13.
Upper and Lower Coal Measures: Illinois.

1876. *Productus punctatus.* White, Powell's Rep. Geol. Uinta Mts., p. 89.
Lower Aubrey group: Confluence of Grand and Green Rivers, Utah.

1877. *Productus punctatus.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 114, pl. 7, fig. 2a-c.
Carboniferous: At and near top of Grass Mountain, Ely Range, 35 miles north of Pioche, Nevada.

1878. *Productus* sp. allied to *P. punctatus.* Etheridge, Quart. Jour. Geol. Soc. London, vol. 34, p. 630.
Carboniferous: Feilden Isthmus, latitude 82° 43'.

1882. *Productus punctatus.* White, 11th Rep. Geol. Surv. Ind., p. 373, pl. 42, figs. 1-3.
Coal Measures: Newport, Indiana.

1883. *Productus punctatus.* Hall, Rep. N. Y. State Geol., for 1882, pl. (19) 50, figs. 14-16.

1883. *Productus Rogersi.* Hall, Rep. N. Y. State Geol., for 1882, pl. (19) 50, figs. 17, 18.
Coal Measures.

1884. *Productus punctatus.* White, 13th Rep. Geol. Surv. Ind., p. 124, pl. 27, figs. 1-3.
Coal Measures: Vermilion, Vigo, Sullivan, Vanderberg, Dubois, Warrick, and Pike Counties, Indiana.

1887. *Productus punctatus.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 48, pl. 2, fig. 29.
Coal Measures: Flint Ridge, Ohio.

1892. *Productus punctatus.* Hall and Clarke, Int. to Study of Brach., pt. 1, pl. 22, figs. 9, 10.
Coal Measures: Mississippi Valley.

1892. *Productus punctatus.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 1, pl. 17A, fig. 21; pl. 19, figs. 14-17.
Upper Coal Measures: Near Kansas City, Missouri; Missouri.

1894. *Productus punctatus.* Keyes, Mo. Geol. Surv., vol. 5, p. 51, pl. 37, figs. 1a-c.
Upper Coal Measures: Kansas City, Missouri.

1897. *Productus punctatus.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 29, pl. 22, fig. 7.
Lower Coal Measures: Conway County, Arkansas.

1900. *Productus punctatus.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 87, pl. 10, figs. 3-3e; pl. 11, fig. 3.
Upper Coal Measures: Kansas City, Turner, Lawrence, Lecompton, Topeka, and Moline, Kansas.

1903. *Productus punctatus.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 368.
Hermosa formation, middle and upper portion: San Juan region, Colorado.

Numerous specimens from the Morrow group evidently belong to the group of *Producti* which has been frequently described from the Pennsylvanian of North America and referred to Martin's species. The material at hand probably could not be differentiated from the common Lower Coal Measures type. It is, however, doubtful whether any of these forms are true *P. punctata* as Martin's figures seem to agree much more closely with

the Mississippian form which is commonly identified as *P. alternata* (Norwood and Pratten). In comparison with the Mississippian shells the specimens in the Morrow collections display a much closer spacing of the concentric spine-bearing bands and a narrower umbonal region with a more acutely pointed beak. In these regards they are more closely related to the Coal Measures form.

When not exfoliated, these shells display an arrangement of the spine bases which is probably characteristic. The posterior half of each concentric band, with the exception of the immediate margin, is occupied by a single row of comparatively large, prostrate spines, directed anteriorly; in front of these are numerous, more closely set, smaller bases of erect spines which occupy the anterior half of each band, again with the exception of the immediate margin. Typically ten or twelve bands occur in the space of 20 mm. although there is considerable variation, apparently following no regular arrangement, in the width of bands in any individual.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137). Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 135, and 140); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Choteau, Oklahoma (Station 298).

Pustula bullata n. sp.

Plate VIII, figures 15-15b.

Description. Shell below medium size, productiform, transversely sub-oval in outline, wider than long, hinge-line not longer than greatest width of valve. Dimensions of the type specimen, an average individual, are: length from hinge-line to anterior margin, 10.1 mm.; distance from umbo to anterior margin, 12.5 mm.; length of hinge-line, ±14.5 mm.; greatest width of valve, 15.8 mm.; convexity of pedicle valve, ±14.5 mm.

Pedicle valve regularly convex from beak to anterior margin giving a semicircular longitudinal section; slightly flattened across vault of visceral region, in transverse section, with moderately steep flanks; cardinal slopes steep, approaching toward their base a position nearly at right angles to the direction of

the small, triangular ears, the latter sharply demarked from visceral portion of valve and quite flat; beak small and incurved, umbonal region not projecting far behind the hinge-line; venter very slightly flattened anteriorly, curving gradually into the rounded main flanks laterally; no mesial sinus present. Surface of valve non-costate, marked only by concentric growth lines which are usually quite conspicuous in all stages of growth and sometimes assume the appearance of concentric ribs or wrinkles, and studded with the bases of comparatively large erect spines irregularly scattered at distances of one to two millimeters from each other, over the entire surface of valve.

Brachial valve unknown.

Remarks. The distinguishing characteristics of this form are the small, flat triangular ears directed at nearly a right angle toward the cardinal slopes, and the character of the surface markings. Its resemblances to other members of the genus are not conspicuously close.

Horizon and locality. Brentwood limestone: near Brentwood (Station 145), and Fayetteville (Station 152), Arkansas.

RHYNCHONELLIDÆ

Genus PUGNOIDES Weller

Pugnoides triangularis n. sp.

Plate XII, figures 12-12c.

Description. Shell small, sub-triangular in outline, valves gently and sub-equally convex, length and breadth about equal, greatest width about one-fourth the distance from anterior margin to beak. Dimensions of two perfect specimens are: length, 8.0 mm., 6.9 mm.; breadth, 8.1 mm., 6.7 mm.; thickness, 4.3 mm., 3.6 mm.

Pedicle valve shallow, the point of greatest convexity slightly posterior to the mid-length of the valve, the surface sloping very slightly toward the anterio-lateral extremities but curving regularly toward the anterior margin, the umbonal region broad and little elevated, the umbonal slopes low but strongly incurved toward the cardinal margin; lateral margins straight or very slightly convex, meeting at the beak in an acute angle where the posterio-lateral edges of the shell are strongly inflected forming a sort of false cardinal area, the lateral margins rounding broadly

in front into the gently convex anterior margin; beak acute, extended conspicuously beyond that of brachial valve, and very slightly incurved; delthyrium triangular, higher than wide, partially closed by a pseudo-deltidium, and with a circular foramen; surface bearing about nine simple angular plications originating in front of the umbo and rapidly increasing in strength to the margins, the three mesial plications depressed below the one on either side which intersects the anterio-lateral extremity of the valve, those beyond decreasing in strength posteriorly.

Brachial valve as deep as, or deeper than, the pedicle, the greatest convexity a little posterior to the middle, the surface curving very gently at first but soon more rapidly toward the lateral margins and anterio-lateral extremities, and curving very slightly toward the anterior margin; beak broad and umbo somewhat flattened transversely, the beak closely incurved beneath that of opposite valve; the surface bearing about 10 plications entirely similar to those of pedicle valve, with usually 4 slightly elevated near the anterior margin to form a mesial fold which quickly becomes obsolete posteriorly. Internally the rostral cavity of the valve bears a strong mesial septum.

The minute surface markings of both valves consist of fine, close-set concentric lines of growth which are about as conspicuous in the umbonal region as near the margins. Shell structure fibrous.

Remarks. This species is probably the immediate ancestor of *Pugnoides uta* (Marcou) abundant in the mid-Pennsylvanian strata and is distinguished from that form by the smaller size, the triangular outline, and the much smaller convexity of the valves which characterize the earlier type.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137). Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135). Morrow formation: near Choteau, Oklahoma (Station 306).

Genus RHYNCHOPORA King

Rhynchopora magnicosta n. sp.

Plate X, figures 11-11c.

Description. Shell below medium size, sub-pyramidal in form, sub-triangular in outline, broader than long, the greatest breadth

near the anterior margin. The dimensions of the holotype, a somewhat distorted individual, are: length, ±11 mm.; breadth, 17.3 mm.; thickness, 13 mm.; width of sinus in front, 11 mm.

Pedicle valve shallow, gently convex in umbonal region, flattened in front of the umbo and deflected very abruptly to the lateral and anterior margins; beak rather broad and closely incurved above that of opposite valve; mesial sinus originating in front of the middle of the valve as a broad, shallow, concave depression which is distinct from the lateral surface of the valve only near the abrupt anterior deflection of the shell where it is depressed below the anterio-lateral extremities of the flattened portion of the valve, produced anteriorly in a broad flattened lingual extension whose surface lies in an acute angle to the plane of the valve; plications simple, rounded or subangular, originating at the beak, in the holotype six occupying the sinus, and five or six each lateral slope.

Brachial valve much deeper than the pedicle, the umbonal region somewhat flattened, the umbonal slopes steep, becoming more abruptly differentiated anteriorly, the greatest convexity at about the mid-length of the valve, the surface sloping from that point to the beak with an increasing curvature and to the anterior margin with an abrupt laterally flattened slope, laterally from the median line the surface is gently convex at first and then curves abruptly to the margins; the beak broad and incurved beneath that of opposite valve; the mesial fold differentiated only near the line of abrupt deflection at the summit of the anterior slope where it is slightly elevated above the anterio-lateral extremities; plications as in opposite valve with seven occupying the mesial fold and about five each lateral slope of the holotype.

Minute surface markings not observable in the material at hand, the shell structure minutely punctate. Internal characters unknown.

Remarks. The material upon which this species is based consists of but two specimens, one a mere fragment and the other slightly distorted. It is, however, quite distinct from the previously described members of the genus. In comparison with *R. carbonaria* McChesney (=*R. illinoisense* Worthen) the smaller number and greater size of the plications, as well as the mark-

edly different outline of the shell, are noteworthy. *R. magnicosta* is, perhaps, more closely related to such Mississippian shells as *R. ? cooperensis* (Shumard) than to either of the two Pennsylvanian species which have been previously described.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 135 and 150).

TEREBRATULIDÆ

Genus DIELASMA King

Dielasma subspatulatum Weller

Plate XI, figures 1-11b; text figure 4.

1914. *Dielasma subspatulatum.* Weller, Ill. Geo. Surv., Mon. I, p. 270, pl. 33, figs. 6-11.
Washington County, Arkansas.

1914. *Dielasma bovidens.* Kozlowski, Annales de Paleontologie, T. 9, p. 88, pl. 9, figs. 61-65.
Upper carboniferous beds: Bolivia.

Fig. 4. A series of eleven cross sections of the rostral portion of *Dielasma subspatutulatum* (x 2½), only the first four of which show the pedicle valve.

At certain of the Arkansas localities this is one of the most abundant species and in all horizons of the Morrow group it is a common fossil. The material at hand includes specimens in all stages of growth from immature forms scarcely 4 mm. in length to individuals in old age which have a length of over 30 mm. All have the typical spatulate outline but considerable variation in the degree of flattening of the anterior portion of the pedicle valve is displayed. In a few individuals a shallow undefined

sinus is developed anteriorly and in some the sinus is quite strong so that they approach somewhat closely to *D. bovidens.*

The specimens which Kozlowski has figured under the name *D. bovidens* Morton are evidently conspecific with the typical *D. subspatulatum* from Arkansas. His excellent illustrations display the spatulate outline and faint or obsolete sinus which characterize the species.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136 and 137). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 134, 135, 138, 140, 150, and 152); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Wagoner (Station 294), Ft. Gibson (Station 303), and Gore (Station 304), Oklahoma.

Dielasma bilobatum n. sp.

Plate XI, figures 14-15b.

Description. Shell small, terebratuliform, greatest width slightly in front of the middle, valves sub-equally and strongly convex. The dimensions of one of the cotypes are: length, +9.0 mm.; width, 7.7 mm.; thickness, 5.8 mm.

Pedicle valve with greatest convexity a little posterior to the mid-length of valve, the surface of valve curving strongly toward the posterior lateral margins and more gently toward the anteriolateral extremities; mesial sinus originating a little behind the middle of the valve and rapidly becoming well-defined and subangular, its floor with a regularly increasing convexity toward the front and its slopes steep and flattened, its anterior portion produced far beyond the margin in a direction nearly at right angles to the plane of union of the valves, causing the anterior outline to be strongly emarginated and the valve to have a distinctly bilobate appearance; beak not known.

Brachial valve about as deep as pedicle, less strongly convex longitudinally, more strongly convex transversely, than opposite valve; beak narrow, pointed, incurved beneath that of opposite valve, cardinal slopes steep; mesial fold originating in front of the mid-length of the valve as a narrow, compressed, rounded ridge which continues to the margin without notable increase in width or elevation, meeting it at the middle point of the strong

emargination resulting from the produced sinus of the pedicle valve.

Surface markings consisting of a few irregularly scattered, rounded, growth lines which are about as numerous in the umbonal region as near the margin. Shell structure finely punctate.

Remarks. Although there is not sufficient material representing this species, only four specimens having come to hand, to permit of determining the internal characters by grinding, it is evident that the form is a *Dielasma.* In one specimen the shell is sufficiently translucent to show the position of the internal lamellae of the brachial valve which present the arrangement of the genus.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135).

Dielasma arkansanum Weller

Plate XI, figures 12-12b.

1914. *Dielasma arkansanum.* Weller, Ill. State Geol. Surv., Mon. I, p. 269, pl. 31, figs. 35-44.
Washington County, Arkansas; Webb City, Missouri.
(Carterville formation?)

Associated with *D. subspatulatum* at two localities were found a few specimens of the form which has been described by Dr. Weller as *D. arkansanum.* This species is an abundant one in the Fayetteville shale and the type material was probably derived from that formation. It is comparatively rare in the Morrow group. No differences are observable between the individuals from the two horizons.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135).

Genus GIRTYELLA Weller

Girtyella? emarginata n. sp.

Plate XI, figures 13-13b.

Description. Shell small, terebratuliform, anterior margin concave, valves strongly convex, greatest width a little in front of the middle. The dimensions of one of the cotypes are: length, 7.0 mm.; width, 6.0 mm.; thickness, 4.2 mm.

Pedicle valve somewhat gibbose, strongly and regularly convex from beak to anterior margin, the slope from the middle of

the valve to the anterior margin slightly flattened transversely, umbonal region broadly convex, the posterior lateral edges of the valve deflected to form a sort of false cardinal area; beak broad, projected conspicuously beyond that of brachial valve, truncated by a large circular foramen; anterior margin truncated by sinus of opposite valve. Internally, the dental lamellae are well developed.

Brachial valve much shallower than pedicle, umbonal region low and broad, surface of valve in front of umbo distinctly flattened transversely except near the margins; beak low and inconspicuous, incurved beneath that of opposite valve; a mesial sinus originating at about the mid-length of the valve and becoming broader and deeper anteriorly with broad rounded transverse outline and with its floor regularly increasing in convexity toward the front. Internally, the median septum is very short and the dental lamellae are well-developed, diverging rapidly from the hinge sockets.

Surface of internal cast smooth, except for one or two growth lines near the margin. Shell structure finely punctate.

Remarks. This species is represented by three internal casts, two of which are nearly complete. It is probably not a *Girtyella* as it lacks the strongly developed median septum of that genus but it cannot be referred to any other of the loop-bearing genera. The form seems to represent a new genus but that point could not be determined without more material than is now at hand.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

SPIRIFERIDÆ

Genus SPIRIFER Sowerby

Spirifer rockymontanus Marcou

Plate XII, figures 1-6.

1858. *Spirifer rocky-montana.* Marcou, Geol. N. A., p. 50, pl. 7, figs. 4-4e. Mountain limestone: Tigeras, New Mexico.

1860. *Spirifer subventricosa.* McChesney, Desc. New Pal. Foss., p. 44. Coal Measures: Big Creek, near New Harmony, Indiana.

1861. *Spirifer Rockymontani.* Newberry, Ives's Colo. Expl. Exped., p. 127. Upper Carboniferous limestone: New Mexico.

1865. *Spirifer Subventricosa.* McChesney, Ill. New Spec. Foss., pl. 1, figs. 4a-b.
1868. *Spirifer opimus.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 35, pl. 1, figs. 4a-b. (Not *S. opimus* Hall, 1858).
Coal Measures: Big Creek, near New Harmony, Indiana.
1874. *Spirifera opima.* Derby, Bull. Cornell Univ. (Science), vol. 1, No. 2, p. 15, pl. 1, fig. 4; pl. 2, fig. 7; pl. 4, fig. 12.
Coal Measures: Bomjardim, Paradao, and Itaituba, Brazil.
1875. *Spirifer (Trigonotreta) opimus?* Meek, Pal. Ohio, vol. 2, p. 329, pl. 19, figs. 14a-e.
Coal Measures: Ohio; Illinois; Iowa; Missouri; West Virginia; and Rocky Mountains.
1876. *Spirifer rockymontanus.* White, Powell's Rep. Geol. Uinta Mts., p. 90.
Lower Aubrey group: Split Mountain Canyon and near Echo Park, Utah.
Upper Aubrey group: Beehive Point, near Horseshoe Canyon, Utah.
1877. *Spirifer (Trigonotreta) opimus?* Meek, U. S. Geog. Expl. 40th Par., vol. 4, p. 88, pl. 9, fig. 6.
Carboniferous limestone: Six miles south of Promontory Station, Promontory Mountains, Railroad Canyon, Moleen Peak; Mount Nebo in Utah; Fossil Hill, White Pine District.
1877. *Spirifer rockymontanus.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 134, pl. 11, figs. 9a-d.
Carboniferous: North Fork of Lewiston Canyon, Oquirrh Range, and on west face of Oquirrh Range, Utah; near Santa Fe, New Mexico.
1887. *Spirifer opima.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 44, pl. 2, fig. 23.
Coal Measures: Flint Ridge, Ohio.
1888. *Spirifera rockymontana.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 231.
Lower Coal Measures: Des Moines, Iowa.
1894. *Spirifera rockymontana.* Keyes, Mo. Geol. Surv., vol. 5, p. 84.
Upper Coal Measures: Kansas City, Missouri.
1897. *Spirifer rockymontanus.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 32.
Lower Coal Measures: White and Crawford Counties, Arkansas.
1899. *Spirifer rockymontanus.* Girty, 19th Ann. Rep. U. S. Geol. Surv., pt. 3, p. 578.
Upper Coal Measures: McAlester and Atoka quadrangles, Indian Territory.
1903. *Spirifer rockymontanus.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 383, pl. 6, figs. 4-7c.
Hermosa formation: San Juan region and Ouray, Colorado.
Weber limestone: Crested Butte district; Leadville district; Grand River region, Colorado.
Robinson limestone: Leadville district, Colorado.
Maroon formation (?): Grand River region, Colorado.

?1910. *Spirifer rockymontanus.* Raymond, Ann. Carnegie Mus., vol. 7, p. 156, pl. 24, fig. 5.
Vanport limestone: New Castle, Pennsylvania.

?1911. *Spirifer rockymontanus.* Raymond, Penn. Topog. and Geol. Surv. Comm., Rep. for 1908-10, pl. 3, fig. 5.
Vanport limestone: New Castle, Pennsylvania.

?1911. *Spirifer rockymontanus.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 308, pl. 8, fig. 10.
Mercer limestone: Somerset, Ohio.

Description. Shell of medium size, about three-fourths as long as wide, somewhat variable in outline, hinge-line less than, equal to, or greater than maximum width anterior to cardinal region, both valves strongly convex. Dimensions of four individuals of varying sizes are:

Length from hinge-line to anterior margin	±15 mm.,	11.6 mm.,	6.0 mm.,	3.8 mm.
Distance from umbonal region of pedicle valve to anterior margin of mesial sinus	±19.5 mm.,	14.2 mm.,	7.1 mm.,	4.4 mm.
Length of hinge-line	28.8 mm.,	+15 mm.,	7.7 mm.,	4.3 mm.
Greatest width of shell	along hinge-line,	17.9 mm.,	9.0mm.,	4.9 mm.
Maximum thickness of shell	+12 mm.,	10.1 mm.,	5.0 mm.,	3.0 mm.
Number of plications in sinus at Anterior margin	9	7	3	1
Number of plications on fold at anterior margin	unknown	8	4	2
Number of plications on either side of fold and sinus at anterior margin	11 or 12;	9 or 10;	6, 7, or 8;	4 or 5

Pedicle valve strongly convex, the longitudinal curvature greater than the transverse, the beak strongly elevated, somewhat narrow and incurved high above hinge-line; cardinal area triangular, concave and transversely striated, delthyrium higher than wide; mesial sinus well-defined, originating on the umbo as a simple depression between two strong plications, enlarging and deepening toward the anterior margin, its plications arising by dichotomous division from those which bound the sinus as well as by bifurcation, the number of plications in the sinus depending upon the size of the shell but in the majority of cases being 7 or 9; lateral plications like those in the sinus, subangular and strong, usually from 9 to 12 occurring on either side of the

sinus, many of them simple but a few, more commonly those adjacent to the sinus, bifurcating.

Brachial valve not so deep as pedicle, its beak small and more closely incurved, cardinal area inconspicuous; mesial fold sharply defined in all stages of growth, originating as a single plication on the umbo which soon bifurcates and becomes more strongly elevated, other plications appearing on the slopes on either side of these two which ordinarily occupy the crest of the fold to the anterior margin, the number of plications on the fold therefore depending upon the age of the shell, but in the majority of cases being about 8; lateral plications as on the pedicle valve.

The minute surface markings are rarely retained but consist of fine radiating striae crossed by fine concentric, wavy, growth lines, the two sets of markings sub-equal in strength.

Remarks. This shell, one of the most abundant in the Morrow collections is characterized by the occasional bifurcations of the lateral plications in which it agrees with the larger specimen figured by Marcou, the first of the two to be mentioned in his text as well as in the legend to the plate and therefore the type of the species. *Spirifer opimus* Hall is apparently a form ordinarily smaller than the adult members of this species and its lateral plications are invariably simple, as inferred from the figures and descriptions. It is not synonymous with *S. rockymontanus*. *S. boonensis,* as described by Swallow and interpreted by Girty[49], is also characterized by simple lateral plications and although similar in outline to the forms with longer hinge-lines which are here referred to *S. rockymontanus* it is evidently distinct from them.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 137, and 149). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 134, 135, 138, 140, 147, 150, and 154); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood (Station 144), and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow formation: near Wagoner (Station 294), Choteau (Stations 295, 297, 298, 302, 306, and 307), Hulbert (Station 299), Ft. Gibson (Station 303), and Gore (Stations 304 and 305), Oklahoma.

Spirifer opimus Hall

Plate XII, figures 7-7c.

1858. *Spirifer opimus.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 711, pl. 28, figs. 1a-b.
Coal Measures: Ohio; Maryland; Iowa; etc.

1883. *Spirifera opima.* Hall, 2nd Rep. N. Y. State Geol., for 1882, pl. (31) 56, figs. 4-7.
Coal Measures: Iowa; Brazil, South America.

1894. *Spirifer opimus.* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 27, figs. 12-13.
Coal Measures: Iowa.

1895. *Spirifer opimus.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 31, figs. 4-7.
Coal Measures: Iowa; Bomjardim, Brazil.

Although this species has been many times included in the synonymy of *S. rockymontanus* it is believed that the two forms are quite distinct and that Hall's species is a valid one. In the material at hand it is represented by a number of specimens, some of which are nearly complete. The original description needs alteration in but one particular to fit these individuals, as obviously Hall intended his statement, "Surface marked by from eight to ten simple, abruptly elevated plications," to mean that number on either side of the fold and sinus. The number of plications in the sinus and on the fold is not, however, limited to three in the material at hand but depends on the size of the individual and may be as great as six.

S. opimus may be distinguished from *S. rockymontanus* by the normally larger and more regular lateral plications which are always simple in the former, as well as by the more transverse outline of the latter. In *S. opimus* the plications of fold and sinus are somewhat less strongly elevated than those on the lateral slopes of the valves while in Marcou's species no difference in strength of plications is discernible.

The dimensions of the largest individual from the Morrow formation referred to this species are: length of brachial valve from hinge-line to anterior margin, 15.0 mm.; length of pedicle valve from umbonal region to anterior margin of mesial sinus, 21.9 mm.; length of hinge-line, 22.8 mm.; greatest width of shell, 24.5 mm.; maximum thickness of shell, 15.3 mm.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 150, and 152). ?Kessler lime-

stone: East Mountain, Fayetteville, Arkansas (Station ?209). Morrow formation: near Gore, Oklahoma (Stations 304 and 305).

Spirifer goreii n. sp.

Plate XII, figures 10-11a.

Description. Shell large, width twice as great as length, greatest width along hinge-line, valves moderately convex. The dimensions of an average individual, in part estimated, are: length from umbonal region of pedicle valve to anterior margin, 21 mm.; length of hinge-line, 53 mm.; thickness of shell, 15 mm.

Pedicle valve moderately and regularly convex longitudinally, the transverse curvature of surface concave upwards on either side of the sinus due to the elevation of the middle part of the shell above the flattened lateral extremities; beak comparatively slender, strongly elevated above cardinal line and incurved over the delthyrium; umbonal region not projecting far beyond the cardinal area; cardinal area about one-tenth as high as long, gently concave, transversely striated, the cardinal margin finely crenulate; delthyrium a large isosceles triangle; mesial sinus originating as a simple depression on the beak, well-defined and bearing two or three plications on the umbo, less well-defined and with more numerous plications anteriorly; lateral slopes of valve bearing from 15 to 20 rounded, rarely bifurcating plications which are strongest adjacent to the mesial sinus and grow fainter toward the cardinal extremities where they may be entirely obsolete.

Brachial valve more shallow than pedicle, gently convex longitudinally, the transverse curvature slightly concave upward on either side of the mesial fold as in the opposite valve; beak inconspicuous, cardinal area very low, umbonal region somewhat strongly elevated above lateral extremities but not projected beyond cardinal line; mesial fold originating on the umbo as a single plication but becoming stronger, though not well-defined, as it expands anteriorly, the plications bifurcating until near the margin there may be 8 or 10; plications of lateral surfaces as on the pedicle valve.

The minute surface markings consist of fine radiating striae, stronger between the plications than on their crests, crossed by equally fine, wavy, concentric lines of growth.

Remarks. This *Spirifer*, although belonging in the general group of *camerati* and presumably in the line of ancestry of *S. cameratus* itself, does not show any indication of the grouping of plications into fascicles which characterizes that species. It seems quite distinct from the other described members of the genus.

A comparison may well be made between this form and the *Spirifer* from the Upper Carboniferous of Bolivia described by Kozlowski[50] as *S. condor*. The latter is larger than *S. goreii* and has more numerous plications in the fold and sinus but presents a similar outline and the same disappearance of the lateral plications near the cardinal extremities. The two forms are perhaps closely related.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Gore, Oklahoma (Station 304).

Genus BRACHYTHYRIS M'Coy

Brachythyris laticosta n. sp.

Plate XI, figures 16-16b.

Description. Shell of medium size or a little larger, sub-circular in outline, the greatest width near the mid-length of the shell, the hinge-line about one-third as great as the width, the cardinal extremities rounded. The dimensions of an average individual are: length, ±28.0 mm.; width, ±27.0 mm.; length of hinge-line, 10.2 mm.; thickness, ±14.0 mm.

Pedicle valve most strongly convex posterior to the middle, the surface sloping abruptly from the umbonal region toward the cardinal margin and more gently toward the lateral and anterior margins, the valve not flattened toward the cardinal extremities; beak pointed, rather slender, and incurved; cardinal area short but high, concave, more strongly curved above near the beak than below toward the hinge-line, the large triangular delthyrium occupying the greater part of the area restricting the latter to two narrow lateral strips which are sharply defined from the convex cardinal slopes on either side; lateral slopes of the valve bearing, on either side of the mesial fold, from 8 to 10 broadly rounded, simple plications separated

by very narrow, rounded, shallow depressions, the plications growing progressively smaller and fainter toward the cardinal extremities where they become obsolete; mesial sinus shallow, originating at the beak as a narrow, simple, well-defined depression, becoming broader anteriorly, with a flat or gently rounded floor occupied by about 3 rounded plications of nearly equal size.

Brachial valve a little less convex than the pedicle, the surface curving sub-equally from about the middle toward the margins; beak projecting only slightly beyond hinge-line, umbonal region not strongly elevated; plications of lateral slopes as in the opposite valve; mesial fold only slightly elevated above the lateral slopes, the depressions which separate it from the adjacent plications being much broader but not deeper than those between any two plications elsewhere on the surface, bearing about 3 sub-equal plications similar to those of the lateral slopes.

Minute surface markings of the shell consist of fine, close-set, wavy, concentric lines of growth which are normally more closely crowded and somewhat stronger toward the anterior margin of the larger shells than elsewhere on the surface. Surface apparently devoid of minute radiate markings.

Remarks. This species is obviously closely related to *B. subcardiiformis* of the Salem limestone, but is distinguished from that form by the absence of false area-like regions on either side of the true cardinal area and by the weaker plications and less elevated fold and sinus of the Morrow form. From *B. suborbicularis* it is distinguished by the proportionately shorter hinge-line.

The species is not very abundant in the Morrow collections, being represented by only seven specimens, all from one locality.

Horizon and locality. Morrow formation: near Choteau, Oklahoma (Station 297).

Genus SQUAMULARIA Gemmellaro

Squamularia perplexa (McChesney)

Plate XII, figures 13-13b.

1856. *Spirifer lineatus.* Hall, Pac. R. R. Rep., vol. 3, p. 101, pl. 2, figs. 6-8. (Not *S. lineatus* Martin, 1809).
Carboniferous: Pecos Village, New Mexico.

1858. *Spirifer lineatus.* Marcou, Geol. N. A., p. 50, pl. 7, figs. 5-5c.
Mountain limestone: Pecos Village and Tigeras, New Mexico.

1859. *Spirifer lineatus.* Meek and Hayden, Proc. Acad. Nat. Sci., Phil., p. 28.
Upper Coal Measures: Leavenworth, Kansas.

1860. *Spirifer perplexa.* McChesney, Desc. New Pal. Foss., p. 43.
Upper Coal Measures: Almost every part of the country where rocks of that age occur.

1861. *Spirifer lineatus.* Newberry, Ives's Colo. Epl. Exped., p. 127.
Upper Carboniferous: Cherty limestone west of Little Colorado River; vicinity of Santa Fe, New Mexico.

1864. *Spirifer lineatus.* Meek, Pal. Cal., vol. 1, p. 13, pl. 2, figs. 6-6d.
Carboniferous: Bass's Ranch, Shasta County, California.

1866. *Spirifer lineatus.* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 408.
Coal Measures: Mississippi Valley.

1866. *Spirifer lineatus* var. *perplexa.* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 408.
Coal Measures: Mississippi Valley.

1866. *Spirifer lineatus* var. *striato-lineatus.* Swallow, Trans. St. Louis Acad. Sci., vol. 2, p. 408.
Upper and Middle Coal Measures: Missouri.

1872. *Spirifer lineatus* ?. Meek, U. S. Geol. Surv. Nebr., pl. 2, figs. 3a-b.
Upper Coal Measures: Platte River, Nebraska.

1874. *Spirifera (Martinia) perplexa.* Derby, Bull. Cornell Univ. (Sci.), vol. 1, No. 2, p. 16, pl. 3, figs. 27,39, 40, 45, 50; pl. 8, fig. 13.
Coal Measures: Bomjardim and Itaituba, Brazil; River Pichia, Peru.

1882. *Spirifer (Martinia) lineatus.* White, 11th Rep. Geol. Surv. Ind., p. 372, pl. 42, figs. 4-6.
Coal Measures: Eugene, Indiana.

1884. *Spirifer (Martinia) lineatus.* White, 13th Rep. Geol. Surv. Ind., p. 133, pl. 27, figs. 4-6.
Coal Measures: Fountain, Park, Vermilion, Vigo, Sullivan, Gibson, Pike, Knox, Posey, Vanderburg, and Warrick Counties, Indiana.

1886. *Spirifer lineatus ?.* Heilprin, 2nd Geol. Surv. Penn., Ann. Rep. for 1885, p. 453.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1887. *Spirifera (Martinia) lineata ?.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 46, pl. 1, figs. 13a-c.
Coal Measures: Flint Ridge, Ohio.

1888. *Spirifer lineatus ?.* Heilprin, Proc. and Coll. Wyo. Hist. and Geol. Soc., vol. 2, pt. 2, p. 269.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania

1888. *Spirifera lineata.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 230.
Lower Coal Measures: Des Moines, Iowa.

1891. *Spirifer (Martinia) lineata.* Whitfield, Ann. N. Y. Acad. Sci., vol. 5, p. 603, pl. 16, figs. 3-5.
Coal Measures: Hocking County, Ohio.

1894. *Spirifera perplexa.* Keyes, Mo. Geol. Surv., vol. 5, p. 84.
Upper Coal Measures: Kansas City, Missouri.

1895. *Spirifera (Martinia) lineata.* Whitfield, Geol. Surv. Ohio, vol. 7, p. 488, pl. 12, figs. 3-5.
Coal Measures: Hocking County, Ohio.

1895. *Spirifer lineatus.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 38, figs. 2, 4, 7, 8.
Coal Measures: Iowa.

1899. *Reticularia perplexa.* Girty, 19th Ann. Rep. U. S. Geol. Surv., pt. 3, p. 577, pl. 72, fig. 1a.
Upper Coal Measures: McAlester quadrangle, Indian Territory.

1903. *Squamularia perplexa.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 392, pl. 6, figs. 8-11c.
Hermosa formation: San Juan region and Ouray, Colorado.
Weber limestone: Crested Butte district and Leadville district, Colorado.
Maroon formation: Crested Butte district, Colorado.
Robinson limestone: Leadville district, Colorado.

1909. *Squamularia perplexa.* Girty, Bull. U. S. Geol. Surv., No. 389, p. 66.
Manzano group, Yeso formation: Mesa del Yeso.
San Andreas formation: San Andreas, New Mexico.

1910. *Squamularia perplexa.* Raymond, Ann. Carnegie Mus., vol. 7, p. 156, pl. 24, figs. 3, 4.
Vanport limestone: New Castle, Pennsylvania.

1911. *Squamularia perplexa.* Raymond, Penn. Topog. and Geol. Surv. Comm., Rept. for 1908-10, pl. 3, figs. 9, 10.
Vanport limestone: New Castle, Pennsylvania.

1911. *Reticularia perplexa.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 308, pl. 8, fig. 11.
Mercer limestone: Bald Knob, Ohio.

This is one of the more common species in the Morrow fauna and is well represented in each of the fossiliferous horizons of the group, being especially abundant in the Brentwood limestone. The individuals are in all stages of growth and vary in length from 3 to 14 mm. In shape and surface markings they are identical with the common Mississippi Valley form.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136 and 149). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 134, 135, 138, 140, and 148); Sawney Hollow, Oklahoma (Station 210).

Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Wagoner (Station 294), Choteau (Station 298), and Ft. Gibson (Station 303), Oklahoma.

Squamularia transversa n. sp.

Plate XII, figures 8-9a.

Description. Shell large, transversely sub-elliptical in outline, length to width about as 3 to 4, greatest width at mid-length of valve, hinge-line a little over half as long as greatest width of valve. The dimensions of a nearly complete pedicle valve are: length, 24.4 mm.; width, +32 mm.; length of hinge-line, 18.5 mm.; convexity of valve, about 11 mm.; height of cardinal area, 4.3 mm. Those of a complete brachial valve are: length, 21.1 mm.; width, 27.8 mm.; convexity, about 7 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the mid-length of the valve, the surface curving abruptly from the elevated umbonal region toward the cardinal margin and more gently toward the lateral and anterior margins, the mid-portion of the valve somewhat flattened anteriorly, the cardinal margins rounding narrowly into the lateral margins which are scarcely defined and curve broadly into the anterior margin which has very little curvature in its mesial portion; beak full, strongly elevated and incurved above the large, open, triangular delthyrium which occupies the middle half of the cardinal area; area concave, with increasing curvature upward from the hinge-line, not sharply differentiated from the umbonal slopes which curve gracefully forward from its margins; a very faint, broad, undefined, mesial sinus, always inconspicuous, is developed in some individuals anteriorly.

Brachial valve less strongly convex than pedicle, its outlines the same, umbonal region much less elevated and consequently with less rapidly curving umbonal slopes; beak full, projected slightly beyond hinge-line, and incurved beneath that of opposite valve; a broad, undefined, inconspicuous, mesial fold generally developed anteriorly.

Surface of both valves marked by concentric bands, whose width is quite variable but with typically about 12 in 5 mm., the bands squamose, imbricated one above the other and bearing

the bases of tiny, close-set spines whose scars appear in some individuals as radiating striae interrupted at the margin of each concentric band; toward the margins the concentric markings may occasionally become more strongly elevated; in some individuals, especially toward the margins, apparently continuous, radiating striae, spaced 7 or 8 in 5 mm., are present though ordinarily quite inconspicuous.

Internally there is no median septum in either valve.

Remarks. In comparison with *S. perplexa,* this species is characterized by its large size and strongly transverse outline. Certain European shells identified as *S. lineata* are nearly or quite as large as this form but are about as long as wide.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 149).

SUESSIIDÆ

Genus SPIRIFERINA D'Orbigny

Spiriferina transversa (McChesney)

Plate XIII, figures 7, 8.

1860. *Spirifer transversa.* McChesney, Desc. New Pal. Foss., p. 42.
Kaskaskia limestone: Buzzard's Roost, Alabama.

1865. *Spirifer transversa.* McChesney, Ill. New Spec. Foss., pl. 6, figs. 3a-c.

1868. *Spirifer transversa.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 34, pl. 6, figs. 3a-c.
Chester limestone: Buzzard's Roost, Alabama.

1874. *Spiriferina transversa.* Derby, Bull. Cornell Univ., (Sci.), vol. 1, No. 2, p. 21, pl. 2, figs. 4-6, 13; pl. 3, figs. 12-14, 17; pl. 5, fig. 4.
Coal Measures: Bomjardim and Itaituba, Brazil.

1883. *Spirifera transversa.* Hall, Rep. N. Y. State Geol., for 1882, pl. (35) 60, figs. 18-25.
Chester group: Buzzard's Roost, Alabama.
Carboniferous: Brazil, South America.

1894. *Spiriferina transversa.* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 31, figs. 1-3.
Chester limestone: Buzzard's Roost, Alabama.
Carboniferous limestone: Itaituba, Brazil.

1895. *Spiriferina transversa.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 35, figs. 19, 20, 23-25.
Chester limestone: Buzzard's Roost, Alabama.
Carboniferous limestone: Itaituba, Brazil.

1914. *Spiriferina transversa.* Weller, Ill. State Geol. Surv., Mon. I, p. 297, pl. 35, figs. 41-49.
Chester group: Chester, Illinois.

A *Spiriferina* which appears indistinguishable from McChesney's species from the Chester limestone is fairly abundant in all three of the fossiliferous Morrow horizons. Certain of the individuals display a more strongly elevated mesial fold than is common in this species but the character is not a constant one and there seems to be no practicable way of separating the Morrow specimens from the Chester forms.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 137, and 149). Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 135, and 140). Kessler limestone: near Brentwood (Station 144), and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow formation: near Ft. Gibson (Station 296), and Choteau (Stations 302 and 307), Oklahoma.

Spiriferina campestris White

Plate XIII, figures 9-10a.

1874. *Spirifernia spinosa (?).* Derby, Bull. Cornell Univ., (Sci.), vol. 1, No. 2, p. 23, pl. 6, figs. 8, 13, 14.
Coal Measures: Itaituba, Brazil.

1874. *Spiriferina spinosa* var. *campestris.* White, Prelim. Rep. Inv. Foss., p. 21.
Carboniferous (Coal Measures): Near Santa Fe, New Mexico; Camp Cottonwood, Lincoln County, Nevada.

1877. *Spiriferina octoplicata.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 139, pl. 10, figs. 8a-c.
Carboniferous: Near Santa Fe, New Mexico; Camp Cottonwood, Lincoln County, Nevada.

1877. *Spiriferina* (undet. sp.). Meek, U. S. Geol. Expl. 40th Par., vol. 4, p. 84, pl. 8, figs. 5-5b.
Carboniferous limestone: Railroad Canyon, Diamond Mountains, Nevada.

1877. *Spiriferina gonionota.* Meek, U. S. Geol. Expl. 40th Par., vol. 4, p. 85.
Carboniferous limestone: Railroad Canyon, Diamond Mountains, Nevada.

1884. *Spiriferina cristata.* Walcott, Mon. U. S. Geol. Surv., No. 8, p. 218, pl. 18, fig. 13. (not fig. 12).
Lower Carboniferous: Eureka District, Nevada.

1897. *Spiriferina cristata.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 32.
Lower Coal Measures: Conway County, Arkansas.
Upper Coal Measures: Sebastian County, Arkansas; Poteau Mountain, Indian Territory.

1903. *Spiriferina campestris.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 396.
Upper portion of Hermosa formation: San Juan region, Colorado.
Weber limestone: Crested Butte district, Colorado.

There can be no doubt that the shells from the Morrow group subsumed under this head are conspecific with the forms from the Hermosa and Weber limestones thus identified by Girty. In one specimen there are seven and eight simple plications on either side of the mesial fold and sinus but in the majority of cases the number is five and six. The surface markings consist of small, close-set pustules which give a coarsely punctate appearance to the shell, and near the margin are fine concentric lines of growth.

Comparing this form with *Sp. spinosa* of the Chester it is seen to have a higher cardinal area and more angular plications as well as smaller and more closely-set pustules. The two species are probably quite distinct.

The dimensions of two individuals, one of average size and one much smaller, are:

Length from umbonal region of pedicle valve to anterior margin	9.8 mm., 7.4 mm.
Length from hinge-line to anterior margin	7.3 mm., 5.7 mm.
Length of hinge-line	10.5 mm., 6.2 mm.
Greatest width	12.6 mm., 8.9 mm.
Thickness	7.3 mm., 5.0 mm.
Height of cardinal area	2.8 mm., 1.1 mm.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 134, 135, and 147); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood, Arkansas (Station 144). Morrow formation: near Ft. Gibson (Stations 296 and 301), Choteau (Stations 297, 302, 306, and 307), Hulbert (Station 299), and Gore (Station 305), Oklahoma.

RHYNCHOSPIRIDÆ

Genus HUSTEDIA Hall & Clarke

Hustedia brentwoodensis n. sp.

Plate XIII, figures 1-3c; text figure 5.

Description. Shell small, sub-trigonal in outline, valves subequally convex, nearly twice as long as wide, the greatest width in front of the middle. The dimensions of three perfect specimens are: length, 8.4 mm., 6.8 mm., 4.9 mm.; width, 4.8 mm., 4.3 mm., and 3.6 mm.; thickness, 5.3 mm., 4.2 mm., and 3.1 mm.

Pedicle valve strongly convex, the surface curving regularly from the beak to the anterior margin but sloping almost vertically from the umbonal region to the lateral margins, the greatest convexity occurring at the mid-length of the valve; anterior margin almost straight, rounding abruptly into the

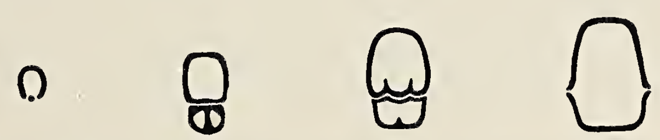

Fig. 5. A series of four cross sections of the rostral portion of the shell of *Hustedia brentwoodensis* (x 2½).

nearly straight lateral margins which converge toward the beak; beak small, pointed and incurved above that of opposite valve, truncated by a small circular foramen; surface marked by 10 to 14 simple, sub-angular plications, originating on the beak, 4 or 5 occupying the middle portion of the shell and intersecting the anterior margin, and 3 or 4 on either lateral slope.

Brachial valve about as convex and having the same shape as the pedicle valve except that it is somewhat shorter; beak closely incurved beneath that of opposite valve; plications similar to those of pedicle valve.

Internally, the inner surface of the pseudodeltidium bears a split tube attached by its closed side to the deltidial plates with its open side directed toward the interior of the shell as shown in figure 5. The umbonal cavity of the brachial valve is occupied by a median septum. Shell structure finely puctate.

Remarks. The appearance of the plications of the surface of this shell presents quite different aspects when exfoliated from that seen when the shell surface is preserved. In the

latter case the plications are sub-angular ridges separated by depressions which are the reverse of the ridges but in the more common exfoliated condition the ridges appear to arise from a flat floor and to be separated by depressions much broader than the ridges themselves. In some instances, in addition, the intercostal depressions seem to be bounded by very faint secondary ridges at either side.

In mature individuals the great thickness of the valves and the flattening of the vertical lateral slopes are very conspicuous.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135); Sawney Hollow, Oklahoma (Station 210). Morrow formation: near Ft. Gibson (Station 301), Choteau (Stations 302 and 307), and Gore (Station 305), Oklahoma.

Hustedia miseri n. sp.

Plate XIII, figures 4-6c.

Description. Shell small, sub-ovate in outline, longer than wide, greatest width near mid-length of valves, valves subequally convex. The dimensions of three perfect specimens are: length, 8.0 mm., 7.0 mm., and 6.0 mm.; width, 6.9 mm., 5.2 mm., and 5.4 mm.; thickness, 5.0 mm., 4.5 mm., and 3.9 mm.

Pedicle valve convex, the greatest convexity occurring about at the mid-length of the valve from which point the surface curves quite strongly toward the posterio-lateral margins and more gently toward the anterio-lateral and anterior margins; beak full, incurved above that of opposite valve, truncated by a small circular foramen; anterior margin very slightly truncated in the middle or even a little emarginated in some individuals, curving broadly into the convex lateral margins on either side; surface bearing about 20 strong, simple, sub-angular, radiating plications of about equal strength throughout the mesial portion of the valve but fainter towards the posteriolateral margins; a very faint undefined mesial sinus developing anteriorly in some individuals and causing the truncation or emargination of the anterior margin.

Brachial valve nearly or quite as deep as the pedicle and of similar curvature and outline; the beak incurved beneath that

of opposite valve; plications similar to those of pedicle valve; the mesial portion of the surface of the valve anteriorly slightly flattened and rarely depressed into a faint sinus.

Internally the structure is identical with that of the foregoing species. Shell structure finely punctate.

Remarks. The varying aspect of the plications, depending upon the exfoliation of the specimens, is the same as that of *H. brentwoodensis,* just described. From that species *H. miseri* may be distinguished by its more numerous and smaller plications, its sub-ovate outline and proportionately greater width.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 137, and 149). Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 135, 140, and 153); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Ft. Gibson (Stations 301 and 303), Choteau (Stations 302 and 306), and Gore (Station 304), Oklahoma.

Genus EUMETRIA Hall

Eumetria vera (Hall)

Plate XII, figures 14-14b.

1858. *Retzia vera.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 704, pl. 27, fig. 3a.
Kaskaskia limestone: Chester, Illinois.

1894. *Eumetria vera.* Hall and Clarke, Int. to Study of Brach., pt. 2, pl. 37, figs. 8, 12.
Chester limestone: Crittenden County, Kentucky.

1894. *Retzia vera.* Keyes, Mo. Geol. Surv., vol. 5, p. 95.
Kaskaskia limestone: Ste. Mary, Missouri.

1895. *Eumetria vera.* Hall and Clarke, Pal. N. Y., vol. 8, pt. 2, pl. 51, figs. 36, 37.
Chester group: Crittenden County, Kentucky.

1909. *Eumetria marcyi.* Bassler, Va. Geol. Surv., Bull. No. 11-A, pl. 29, figs. 4, 5.

1914. *Eumetria vera.* Weller, Ill. State Geol. Surv., Mon. I, p. 444, pl. 76, figs. 13-17.
Chester group: Chester, Illinois.

Three specimens of a *Eumetria* are present in the Morrow collections, all from the Brentwood limestone, and are referred with considerable confidence to this species. The form represented is smaller than the average among this species but agrees

perfectly with the Chester individuals in outline and shape. About 42 simple plications are present on each valve.

The dimensions of the figured specimen are: length, 10.0 mm.; breadth, 8.2 mm.; thickness, 5.4 mm.

Horizon and locality. Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 148, 152, and 153).

ATHYRIDÆ

Genus COMPOSITA Brown

Composita ozarkana n. sp.

Plate XIII, figures 11-15c.

Description. Shell typically medium though in some instances small in size; sub-ovate in outline, the larger specimens not uncommonly becoming subquadrate or subpentagonal, the width ordinarily as great as or slightly greater than the length but in some individuals less than the length, the greatest width normally slightly anterior to the mid-length of the shell but rarely slightly posterior thereto, fold and sinus developed anteriorly. The dimensions of three specimens, the largest of which is the one selected as the holotype, are: length, 20.8 mm., 16.4 mm., 10.7 mm.; breadth, 21.0 mm., 16.2 mm., 10.8 mm., thickness, 13.8 mm., 10.6 mm., 6.7 mm.

Pedicle valve most convex in and near the umbonal region, the surface curving abruptly toward the cardinal margin and more gently toward the lateral and anterior margins, the convexity decreasing anteriorly from the umbo until close to the margin where it may be somewhat increased over a short space; the mesial sinus originating on the umbo at a point one-sixth to one-fifth the distance from beak to anterior margin as a faint narrow groove which deepens anteriorly and becomes a sulcus, ordinarily fairly well-defined, in the bottom of the broad, ill-defined, shallow sinus, which toward the anterior margin occupies approximately one-fourth the width of the valve, with poorly defined lateral margins; in some specimens faint ridges separate the mesial depression from the lateral portions of the shell but these may be observed only at and near the anterior margins, as they do not originate until beyond the umbonal region; beak strongly incurved, truncated obliquely to the plane

of the valve, and perforated by a large subcircular foramen; delthyrium concealed.

Bracial valve faintly trilobate, nearly or quite as convex as the pedicle, greatest convexity posterior to the middle; mesial fold originating near the umbo but not becoming defined until anterior to the middle, rounded or slightly flattened on top, rarely marked by a faint median groove toward the anterior margin, but more commonly with its median line defined by an indenture of the lines of growth along its middle; on each side of the fold there is a faint, ill-defined, rounded sinus originating in front of the middle and becoming more prominent toward the margins; beak strongly incurved beneath that of the opposite valve.

The surface of both valves is marked by close-set, concentric lines of growth with the fourth or fifth lines stronger than the intermediate ones when the preservation is such as to show the latter; the stronger growth lines are sometimes crowded toward the front; ordinarily the shell is otherwise smooth but in some of the specimens faint radiating striae may be observed running from beak to margin.

Remarks. Like all other species of *Composita* this is an exceedingly variable one and embraces individuals which closely resemble certain forms ordinarily identified as *C. trinuclea, C. subquadrata,* or *C. subtilita.* Typical forms embodying what may be called the average characters of the species are, however, notably different from the typical forms of those species. *C. ozarkana* differs from *C. trinuclea* in its larger size, its greater breadth in proportion to its length, and the generally fainter and more poorly defined character of its fold and sinus. From *C. subquadrata* it may be differentiated by the presence of the sulcus in the sinus of the pedicle valve and by its less quadrate outline. In comparison with the plesiotypes of *C. subtilita, C. ozarkana* is characterized by the greater transverse convexity of the pedicle valve, the slightly anterior extension of the mesial sinus, the weakness of the lateral sinuses bordering on the fold of the brachial valve, and the fact that the greatest width of the shell is near the middle point instead of notably anterior to it as in the Coal Measures form.

Immature individuals may be indistinguishable from the smaller specimens of *C. wasatchensis* but the specific characters ordinarily are apparent in those which have attained a length of 5 mm. Specimens of that size begin to show a lateral broadening and the initial development of the fold and sinus which distinguish them from specimens of *C. wasatchensis* of the same size, although these somewhat indefinite characters would not serve to separate them from immature individuals of the three species mentioned in the preceding paragraph.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 137, and 139). Brentwood limestone: near Fayetteville (Stations 134, 135, 138, 147, 148, 152, and 153), Brentwood (Station 145), and West Fork (Station 154), Arkansas; Sawney Hollow, Oklahoma (Station 210). Kessler limestone: near Brentwood, Arkansas (Station 144). Morrow formation: near Wagoner (Station 294), Choteau (Stations 297, 302, 306, and 307), Ft. Gibson (Stations 301 and 303), and Gore (Stations 304 and 305), Oklahoma.

Composita wasatchensis (White)

Plate XIV, figures 7-10b.

1874. *Rhynchonella Wasatchensis.* White, Prelim. Rep. Inv. Foss., p. 19. Carboniferous (Coal Measures): Wasatch Range, Utah.

1877. *Rhynchonella Wasatchensis.* White, U. S. Geog. Surv. w. 100th Merid., vol. 4, p. 130, pl. 9, figs. 3a-d. Carboniferous: Rock Canyon, Wasatch Range, near Provo, Utah.

Description. Shell small, sub-circular in outline, valves subequally convex, greatest thickness of shell posterior to the middle, fold and sinus absent or faintly developed. The dimensions of four typical individuals are: length, 12.5 mm., 9.1 mm., 6.3 mm., 3.5 mm.; width, 12.1 mm., 8.4 mm., 6.0 mm., 3.3 mm.; thickness, 7.0 mm., 4.7 mm., 3.6 mm., 2.1 mm.

Pedicle valve most convex in and near the umbonal region, the surface curving abruptly toward the cardinal margin and more gently toward the lateral and anterior margins, the convexity decreasing anteriorly; beak moderately arched and strongly incurved over beak of brachial valve, truncated by a comparatively large sub-circular foramen which encroaches upon the umbo; mesial sinus absent or represented in some individuals

by a faint mesial line which seems to be a character of the shell structure rather than a depression in the shell surface or it may be represented anteriorly by a slight broad downward flexure of the line of contact between the valves.

Brachial valve almost exactly circular in outline, slightly less convex than the pedicle valve, transverse curvature ordinarily a little stronger than the longitudinal; beak somewhat prominent, especially in the more mature individuals, because of a slight flattening toward either side.

Surface of both valves marked by faint concentric lines of growth which in most cases are nearly as prominent in the umbonal region as toward the anterior margin. Shell structure fibrous, giving many specimens the appearance of being covered with exceedingly fine thread-like striae.

Remarks. This form—one of the most numerous in the Brentwood limestone and abundant in all fossiliferous horizons in the Morrow group—is frequently observed at higher and lower elevations in the Carboniferous formations of the southern and western Mississippi valley. It is apparent, as pointed out by Girty[51], that the great anterior thickening of the shell, so conspicuous in White's figures, is due to old age and cannot be considered a specific character. Such a thickening is absent from the Arkansas forms. It is probable that *C. humilis* of the Madison limestone and the Moorefield shale is conspecific with the forms here described.

Doubtless the smaller individuals included under this title embrace also the immature members of some or all of the other species of this genus found in the Morrow collections, as their specific characters are not acquired until a length of about 5 mm. is attained.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136 and 149). Brentwood limestone: near Fayetteville, Arkansas (Stations 134, 135, 148, and 153); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Ft. Gibson (Stations 301 and 303), and Choteau (Station 302), Oklahoma.

Composita ovata n. sp.

Plate XIV, figures 6-6c.

Description. Shell medium size, sub-oval in outline, width typically much less than length but approaching the latter dimension in some individuals, greatest width more or less anterior to middle, convexity of valves sub-equal and comparatively low. The dimensions of two nearly perfect individuals are: length, 27.3 mm., 21.8 mm.; width, 26.8 mm., 18.0 mm.; thickness, 13.7 mm., 10.7 mm.

Pedicle valve broadly convex, curving sharply from the umbo toward the cardinal margin but sloping gently toward the lateral and anterior margins; mesial sinus originating in the umbonal region about one-fourth the distance from beak to anterior margin as a narrow, well-defined sulcus which continues to the margin with little or no increase in depth or width; the mesial portion with a breadth about two-fifths that of the greatest width of the valve, produced anteriorly and with little or no transverse curvature, the longitudinal convexity continuing without notable change to the anterior margin of the extension which has a broadly spatulate outline; beak prominent, incurved above that of brachial valve, truncated by a large, circular foramen encroaching upon the umbo; delthyrium concealed.

Brachial valve more strongly curved transversely than longitudinally, greatest convexity near the umbo; mesial fold broad and undefined, originating in the umbonal region and increasing in width anteriorly until it occupies about two-fifths the width of the valve, gently rounded on top with lateral slopes increasing slightly in steepness and height toward the anterior margin; beak somewhat tumid, incurved over the delthyrium of the pedicle valve.

Surface of both valves covered by fine, close-set concentric lines of growth with occasional lines much stronger than the intermediate ones and crossed by fine thread-like radiating striae.

Remarks. Individuals included in this species vary considerably in outline from longitudinally oval to nearly sub-circular but all are characterized by the comparatively low longitudinal convexity resulting from the slight thickness of the shell. The absence in the pedicle valve of the broad mesial sinus bordered

anteriorly by lateral ridges and in the brachial valve of the two lateral sinuses defining the mesial fold serve to distinguish *C. ovata* from the larger individuals of *C. ozarkana* to which it appears to be closely related.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 139, and 149). Brentwood limestone: near Fayetteville, Arkansas (Station 135). Kessler limestone: near Brentwood (Station 144), and on East Mountain, Fayetteville (Station 209), Arkansas. Morrow formation: near Choteau, Oklahoma (Station 302).

Composita deflecta n. sp.

Plate XIV, figures 1-3b.

Description. Shell slightly under medium size, sub-pentagonal in outline, longer than wide, greatest width anterior to middle, valves sub-equally convex, anterior margin truncated by a sharp downward deflection of the mesial portion of pedicle valve. The dimensions of three nearly perfect individuals are: length, 20.2 mm., 19.9 mm., 16.9 mm.; width, 17.6 mm., 18.5 mm., 15.4 mm.; thickness, 10.2 mm., 10.8 mm., 8.7 mm.

Pedicle valve strongly convex in the umbonal region but with lessened curvature anteriorly and laterally; mesial sinus consisting of a sulcus, ordinarily faint and ill-defined, originating in the umbonal region at some distance from the beak and continuing to the anterior margin with little increase in depth or width; the middle three-fifths of the anterior portion of the valve notably extended and deflected sharply downward forming an angle of 50° to 80° with the plane of union of the two valves and truncating the anterior margin; deflected area outlined by two lateral ridges, not elevated above the valve surface but formed by the downward flexure in front and the normal lateral curvature behind, converging rapidly posteriorly but not defined in the mesial portion of the valve, anterio-lateral margins bordering the deflected extension flattened or crimped upward along line of contact between valves; beak somewhat elevated, not tumid, incurving above that of brachial valve less markedly than is common among Compositas, truncated by the sub-circular foramen; delthyrium triangular, not always concealed by beak of brachial valve.

Brachial valve with greater convexity transversely than longitudinally; mesial fold obsolete, the middle portion of the valve truncated to fit the flexure of the pedicle valve, the anterio-lateral margins extended with slightly increased curvature to fill in the angles beneath the lateral ridges of the opposite valve, anterior margin flattened or slighty crimped upward along line of contact between valves; beak not prominent, incurving beneath that of opposite valve.

Surface of both valves marked by close-set concentric lines of growth crossed in many specimens by fine thread-like radiating striae.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Composita gibbosa n. sp.

Plate XIII, figures 16-18c.

Description. Shell small, gibbose, sub-oval in outline, longer than wide, greatest width at the middle or slightly anterior thereto, an undefined fold and sinus developed anteriorly. The dimensions of four typical specimens are: length, 12.1 mm., 11.4 mm., 11.2 mm., 9.5 mm.; width, 10.2 mm., 10.4 mm., 9.5 mm., 8.2 mm.; thickness, 7.4 mm., 6.7 mm., 7.6 mm., 6.0 mm.

Pedicle valve broadly ovate in outline, surface curving abruptly from umbo toward cardinal margin and more gently toward lateral and anterior margins, mesial sinus shallow, undefined, originating in front of the middle and extended anteriorly with an increasing convexity to meet the brachial valve, in most specimens a faint narrow sulcus originates on the umbo and continues to the front occupying the bottom of the sinus; beak somewhat tumid, incurved above that of opposite valve, truncated by the sub-circular foramen.

Brachial valve sub-circular in outline, strongly convex transversely and less strongly longitudinally; mesial fold obsolete or faintly developed anteriorly, anterio-lateral areas more strongly convex than the middle portion of valve; beak not prominent, incurved beneath that of pedicle valve.

Surface of both valves covered by concentric lines of growth which ordinarily are strongly elevated, especially toward the

margin where a notable thickening of the shell may be observed in many individuals. Fine thread-like radiating striae may be observed in some specimens.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 135 and 152).

Composita biplicata n. sp.

Plate XIV, figures 5-5c.

Description. Shell below medium size, sub-pentagonal in outline, longer than wide, greatest width near middle, valves subequally convex, mesial fold and sinus developed anteriorly and bearing a strong plication along the middle line, anterior margin corrugated. The dimensions of the holotype are: length, 22.6 mm.; width, 19.7 mm.; thickness, 11.5 mm.

Pedicle valve most strongly convex in the umbonal region, the surface curving abruptly toward the cardinal margin and less strongly toward the lateral and anterior margins; mesial sinus originating near the middle of the valve and consisting of two rounded sinuses, slightly increasing in width and depth toward the margin, which border a fairly strong mesial fold, the inner margins of the sinuses more sharply defined than the lateral, and the convexity of their floors increasing anteriorly; beak somewhat tumid and incurved above that of opposite valve, truncated in a plane at an angle with the plane of union of the valves by a large sub-circular foramen.

Brachial valve more strongly convex transversely than longitudinally; mesial sinus originating in front of the middle and bordered by two faintly outlined lateral ridges converging gently toward the umbo and defined by the stronger curvature of the anterio-lateral margins and the mesial fold; beak full but not prominent, incurved into delthyrium of pedicle valve.

Surface of both valves marked by concentric lines of growth, in most cases elevated above shell surface and more numerous toward the anterior margin than on the umbo, crossed by very fine, thread-like, radiating striae.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Composita transversa n. sp.

Plate XIV, figures 4-4c.

Description. Shell small, sub-oval in outline, wider than long, valves strongly convex, fold and sinus absent but anterior margin slightly depressed in its mesial portion. The dimensions of two nearly perfect individuals are: length, 10.5 mm., 8.9 mm.; width, 11.2 mm., 10.0 mm.; thickness, 7.2 mm., 5.6 mm.

Pedicle valve with greatest convexity in the umbonal region, the surface curving abruptly toward the cardinal margin and less sharply toward the lateral and anterior margins except that the convexity may be suddenly increased near the margin by the thickening of the shell in old age; mesial fold absent though in some specimens there is a faint mesial line which seems to be a character of the shell structure rather than a depression in the shell surface; the line of union of the two valves slightly curved downward over the middle third of the anterior margin; beak somewhat prominent and strongly incurved over that of brachial valve, foramen small, sub-circular.

Brachial valve equally as convex as pedicle, greatest curvature in the umbonal region and decreasing toward the lateral margins; mesial fold absent but curvature of the valve corresponding to that of the anterior line of contact between the valves; beak not prominent, incurved beneath that of opposite valve, marginal thickening of shell same as in pedicle valve.

Surface of both valves marked by concentric lines of growth, ordinarily somewhat elevated, especially toward the margins, crossed by radiating thread-like striae.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137). Brentwood limestone: Fayetteville, Arkansas (Station 148).

PELECYPODA

SOLENOMYACIDÆ

Genus SOLENOMYA Lamarck

Solenomya sp.

Plate XV, figure 8.

The genus *Solenomya* is represented in the Morrow collections by an imperfect right valve preserved as an internal cast with

small portions of the shell clinging to its surface. The form was of medium size, transversely elongate, and moderately convex, with no distinct umbonal ridge. The cardinal and ventral margins are nearly straight and parallel and the posterior portion of the valve is extended considerably behind the inconspicuous beak situated at the posterior extremity of the cardinal margin. The surface of the shell was apparently nearly smooth with faint concentric lines of growth discernible anteriorly. In general appearance the valve resembles that from the Moorefield shale described by Girty[52] as *Solenomya? sp.* but is much smaller.

Horizon and locality. Kessler limestone: near Brentwood, Arkansas (Station 144).

SOLENOPSIDÆ

Genus SPHENOTUS Hall

Sphenotus halensis n. sp.

Plate XV, figure 5.

Description. Shell small, transversely sub-trapezoidal in outline, the greatest length (near the ventral margin) about twice the height (measuring along a line normal to the hinge-line and situated near the posterior margin). Left valve: hinge-line straight and little more than half the length of valve below, posterior margin obliquely truncated above and rounding into the ventral margin below; ventral margin nearly straight with a slight sinuosity immediately in front of the middle and slightly oblique to the hinge-line so that if produced the two would meet about 4 cm. in front of the beak; anterior margin slightly concave above, beneath the umbo, and rounding broadly into the ventral margin below; beak not prominent, situated at anterior end of hinge-line; umbonal ridge stronger and sharper near beak and more rounded, though still well-defined as it nears the posterio-ventral angle, gently curved so that it is slightly convex upward; a second, fainter and less well-defined, ridge extends from umbo to posterior margin, bisecting the angle between the large umbonal ridge and the hinge-line; a broad, shallow, undefined sinus originates on the umbo and, continuing downward, meets the ventral margin somewhat in front of the middle. Right valve unknown.

Internally, the anterior adductor muscle-scar is comparatively large and deep and is bounded behind by a sharp crescentic ridge; the surface of the internal cast is crossed by irregular undulations parallel to the margins of the valve.

In the material at hand only a small portion of the external surface of the valve, adjacent to the cardinal margin, is preserved. It is marked by close-set, concentric striations parallel to the posterior margin.

Dimensions of type, a left valve, are: length, 8.0 mm.; height, 4.0 mm.; convexity of valve, about 1.5 mm.; length of hinge-line, 4.5 mm.

Remarks. It is plainly evident that this species is congeneric with the forms to which in 1885 Hall[53] gave the name *Sphenotus* but unfortunately the validity of that genus is not quite clear. Hind[54] believes it to be a synonim of *Sanguinolites* and if his diagnosis of the latter is correct such would seem to be the case.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

GRAMMYSIIDÆ

Genus EDMONDIA De Koninck

Edmondia subtruncata Meek

Plate XV, figure 2.

1872. *Edmondia subtruncata.* Meek, U. S. Geol. Surv. Nebr., p. 215, pl. 2, fig. 7.
Upper Coal Measures: Rock Bluff, Nebraska; Atchison, Kansas.
Lower Coal Measures: Illinois.

1894. *Edmondia subtruncata.* Keyes, Mo. Geol. Surv., vol. 5, p. 127.
Upper Coal Measures: Kansas City, Missouri.

1899. *Edmondia subtruncata?* Girty, U. S. Geol. Surv., 19th Ann. Rep., pt. 3, p. 580.
Upper Coal Measures: Atoka Quadrangle, Indian Territory.

1903. *Edmondia subtruncata.* Girty, U. S. Geol. Surv., Prof. Paper 16, p. 448.
Upper portion of Hermosa formation: San Juan region, Colorado.

Description. Shell longitudinally sub-ovate, outline of dorsal margin very slightly convex in the middle and curving more gently toward the anterior margin than toward the posterior, the latter margin curving abruptly into the cardinal margin; valves moderately convex, the greatest convexity being near the middle, surface of valves regularly curved, somewhat abruptly so

toward the cardinal portions and more gently toward the anterior and posterior margins, the middle portion of the valve slightly flattened dorsally; beaks rather depressed, convex, and placed nearer the anterior end than the middle.

Surface of internal cast marked with distinct, concentric, irregular undulations which are less distinctly shown on the exfoliated surface of the valve. The distance from crest to crest of the undulations, throughout the middle of the valve, averages about 1.5 mm.

Dimensions of the two imperfect specimens are approximately: length, 34.5 mm., 31.5 mm.; height, 29.0 mm., 21.5 mm.; convexity, 11.5 mm., 9.0 mm.

Remarks. The material referred to this species consists of a somewhat incomplete cast of the interior of a left valve and an imperfect left valve of another individual which is strongly exfoliated, both from a single locality in the Kessler limestone. *E. subtruncata* resembles *E. aspinwallensis* but may be differentiated from it by the proportionately greater length, less elevated beaks, the dorsal flattening of the middle portion of the valve, and the nearly straight dorsal outline.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Edmondia maccoyii Hind?

Plate XV, figure 10.

1855. *Edmondia scalaris.* M'Coy, Brit. Pal. Foss, p. 502, pl. 3H, fig. 6. (non Venerupis scalaris M'Coy, 1844).
Carboniferous limestone: Lowick, Northumberland, England.

1888. *Edmondia scalaris* (pars). Etheridge, Brit. Foss., pt. i., Paleozoic, p. 284.

1899. *Edmondia MacCoyii.* Hind, Brit. Carb. Lamell., vol. i., pt. iv., p. 329, pl. XXXVI., figs. 8, 23-30.
Carboniferous limestone: Settle, Yorkshire; Thorpe Cloud, Castleton and Park Hill, Darbyshire; Narrowdale, Staffordshire; The Coomb and Lowick, Northumberland, England.
Lower Limestone of Auchenskeith and Dockra, Scotland.
Carnteel, Tyrone, Ireland.
Millstone Grit series: Cayton Gill beds, near Harrogate, England.

A left valve of an *Edmondia* from the Kessler limestone, preserved as both an internal cast and external mold, neither of which is quite complete, is referred with a fair degree of con-

fidence to Hind's species. The internal cast shows the typical subquadrate outline of the shells figured by Hind though it is much smaller than most of his figures, agreeing closely in size with figure 8. The groove which represents the thickened ridge of the hinge plate is well shown and the surface markings of concentric grooves and ridges are present. The external mold has preserved the surface ornamentations to the last detail and these agree with the description of the types except that the angular ridges are from 16 to 18 in number. Hind notes, however, that there is "a great amount of variation in the size, number, and proximity of the concentric ribs."

The dimensions of the Kessler form are approximately: length, 11.5 mm.; height, 8.6 mm.; convexity, 4.1 mm.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

NUCULIDÆ

Genus NUCULA Lamarck

Nucula parva McChesney

Plate XV, figure 21.

1860. *Nucula parva.* McChesney, Desc. New Pal. Foss., p. 54.
Coal Measures: Danville, Illinois.

1865. *Nucula parva.* McChesney, Ill. New Spec. Foss., pl. 2, figs. 8a-c.

1868. *Nucula parva.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 39, pl. 2, figs. 8a-c.

1873. *Nucula parva.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 589, pl. 26, fig. 8.
Coal Measures: Danville, Illinois.

1888. *Nucula parva.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 233.
Lower Coal Measures: Des Moines, Iowa.

1894. *Nucula parva.* Keyes, Mo. Geol. Surv., vol. 5, p. 121.
Upper Coal Measures: Kansas City, Missouri.

1897. *Nucula parva.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 35.
Lower Coal Measures: Conway County, Arkansas.
Upper Coal Measures: Crawford County, Arkansas.

1914. *Nucula parva.* Price, West Va. Geol. Surv., Preston County Rep., p. 514.
Ames limestone: Throughout the County.
Brush Creek limestone: Grant district; 0.9 mile west of and 0.9 Mile northeast of Bruceton Mills, Garrett County, Maryland, 4 miles northwest of Oakland, and B. & O. R. R. cut at Hutton.

A right valve from the Hale formation, although not as strongly convex as the more mature individual figured by McChesney, agrees so closely with other specimens from the Danville locality that there can be no doubt that it belongs to this species. The fine threadlike concentric striae are ordinarily regular but near the margins two or three may be crowded together and form faint concentric ridges across the surface of the shell. The shell itself is comparatively thick, as is common in this genus.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137).

Nucula kessleriana n. sp.

Plate XV, figures 22, 22a.

Description. Shell small, transversely oval, length to height about as seven to four, convexity moderate; anterio-dorsal margin broadly convex, rounding abruptly into the convex ventral margin with the anterior extremity narrower and slightly more produced than the posterior; posterio-dorsal margin gently concave near the beak and rounding broadly to the ventral margin; beak full and prominent, moderately elevated above the hinge-line, situated a little behind the middle and directed very slightly posteriorly; hinge plate represented in the internal cast by a deep groove beneath the beak with the impressions of at least six close-set teeth; surface of cast smooth; surface of shell not ornamented and marked only by faint concentric growth lines.

Dimensions of the type specimen are: length, 14.7 mm.; height, 8.8 mm.; convexity of left valve, about 3.3 mm.

Remarks. This species, based upon a left valve preserved as both an internal cast and external mold, is referred to *Nucula* rather than to *Yoldia,* in the absence of information as to the pallial line, because the valves do not gape. It is unlike all other Carboniferous species of these genera, distinguished from those forms with a similar shape by its lack of sculpturing and from the smooth forms by its shape.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Nucula sp.

Description. Shell small, sub-triangular in outline, convexity low; anterio-dorsal margin nearly straight, meeting the ventral margin in an acute angle; posterio-dorsal margin slightly convex and much shorter than anterio-dorsal; ventral margin convex, curving abruptly into the anterio-dorsal and more gently into the posterio-dorsal margin; beak not tumid and only slightly elevated above the hinge-line, situated behind the middle and directed posteriorly; taxodont dentition indicated by impressions of teeth along hinge-line; surface of cast smooth.

Remarks. The cast of a left valve of a *Nucula* upon which this description is based bears strong resemblance to *N. illinoisensis* Worthen and to *N. montpelierensis* Girty but its characters are not sufficiently defined to permit of accurate specific determination.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

LEDIDÆ

Genus LEDA Schumacher

Leda bellistriata Stevens ?

Plate XV, figure 19.

1858. *Leda bellistriata.* Stevens, Am. Jour. Sci., 2nd ser., vol. 25, p. 261.
Coal Measures: Danville, Illinois; Summit, Ohio.

1858. *Nucula (Leda) Kazanensis.* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 190. (Not *N. kazanensis* Verneuil, 1845.)
Upper and Lower Permian: Valley of Cottonwood and near Smoky Hill Fork, Kansas.

1858. *Leda bellistriata.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 717, pl. 29, figs. 6a-d.
Lower Coal Measures: Illinois.

1862. *Leda bellistriata.* Winchell, Proc. Acad. Nat. Sci., Phil., p. 419.
Marshall Group: Moscow, Michigan.

1865. *Leda bellistriata.* Winchell, Proc. Acad. Nat. Sci., Phil., p. 128.
Marshall Group: Hillsdale, Michigan.

1869. *Leda bellistriata ?.* Winchell, Safford's Geol. Tenn., p. 444.
Shales just above Black shale: Hickman and Maury Counties, Tennessee.

1870. *Leda bellistriata ?.* Winchell, Proc. Am. Phil. Soc., vol. 11, p. 256.
Waverly Group: Tennessee.

1884. *Nuculana bellistriata.* White, 13th Rep. Geol. Surv. Ind., p. 146, pl. 31, figs. 8-9.
Coal Measures: Vermilion, Sullivan, Vandenburg, and Warrick Counties, Indiana.

1887. *Nuculana bellistriata.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 40, pl. 4, fig. 26.
Coal Measures: Flint Ridge, Ohio.

1888. *Nuculana bellistriata.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 232.
Lower Coal Measures: Des Moines, Iowa.

1894. *Nuculana bellistriata.* Keyes, Mo. Geol. Surv., vol. 5, p. 122, pl. 45, figs. 4a-b.
Upper Coal Measures: Gentry and Kansas City, Missouri.

1897. *Nuculana* aff. *bellistriata.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 35.
Upper Coal Measures: Scott County, Arkansas.

1900. *Nuculana bellistriata.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 148, pl. 20, figs. 14-14b.
Upper Coal Measures: Kansas City, Rosedale, Lawrence, and Topeka, Kansas.

1903. *Leda bellistriata ?.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 442.
Upper portion of Hermosa formation: San Juan region, Colorado.

1911. *Leda bellistriata.* Mark, Bull. Sci. Lab. Den. Univ., vol 16, p. 310, pl. 9, fig. 5.
Mercer limestone: Limestone Hollow, Flint Ridge, Ohio.

Description. Shell transversely sub-oval, moderately convex, length to height about as seven to four; posterio-dorsal margin slightly concave and produced posteriorly meeting the ventral margin in an acute angle; ventral margin convex, somewhat strongly anteriorly and more gently posteriorly, joining the anterio-dorsal margin in a broad curve; anterio-dorsal margin broadly convex; beak full but not elevated far above hinge-line, situated in front of the middle, greatest convexity a little in advance of the middle; surface ornamented by close-set, concentric, angular ridges separated by rounded grooves and occurring about 3 to the millimeter in the ventral portion of the shell.

The dimensions of the specimen figured are approximately: length, 13.5 mm.; height, 8.2 mm.; convexity of valve, 2.3 mm.

Remarks. These shells are not so transversely elongate as the Coal Measures forms commonly referred to this species but the dimensions of the type specimen, as given by Stevens, are: length, 0.7 inch; height, 0.4 inch; giving an outline closely sim-

ilar to that of the material at hand. It is possible that the forms from the Morrow group are closer to Stevens's type than many of the specimens which have been thus identified.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136 and 137).

PARALLELODONTIDÆ

Genus PARALLELODON Meek

Parallelodon sangamonensis (Worthen)

1890. *Macrodon sangamonensis.* Worthen, Geol. Surv. Ill., vol. 8, p. 123, pl. 21, figs. 3-3a.
Coal Measures: Roll's Ford, Sangamon County, Illinois.

1894. *Macrodon sangamonensis ?.* Keyes, Mo. Geol. Surv., vol. 5, p. 121, pl. 46, fig. 2.
Upper Coal Measures: Kansas City, Missouri.

1900. *Macrodon sangamonensis ?.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 146, pl. 20, figs. 2-2b.
Upper Coal Measures: Turner, Wyandotte County, Kansas.

1911. *Parallelodon sangamonensis.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 310, pl. 9, fig. 10.
Mercer limestone: Bald Knob, Ohio.

An imperfect internal cast from the Kessler limestone is referred with considerable confidence to this species. The strong radiating costae over the posterior portion of the shell, which become successively weaker anteriorly, and the restriction crossing the valve from umbo to ventral margin with the consequent slight sinuosity in the latter, are well shown. The shell was probably smaller than most of the forms thus identified as its length could not have been much over 19 mm. when restored.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Parallelodon pergibbosus n sp.

Plate XV, figure 6.

Description. Shell below medium size, transversely subelliptical in outline, very inequilateral, strongly convex, nearly three times as wide as high, hinge-line nearly as long as greatest width of valve; cardinal margin straight and met by the anterior margin in a right angle, the anterior outline curving gracefully into the ventral margin which is nearly straight and parallel

to the dorsal margin, slightly sinuous a little in front of the middle and rounding gradually into the somewhat produced posterior outline which curves abruptly upward and forward meeting the hinge-line in an obtuse angle; beak full, elevated above the hinge-line and situated less than one-fourth the length of the cardinal line behind the anterior extremity of the valve; umbo tumid and distended laterally; umbonal ridge extending obliquely backward, merging with the posterior extension of the valve, the portion of the shell above the umbonal ridge moderately flattened but not so much so as the small area adjacent to the anterio-dorsal extremity, a distinct constriction originating on the umbo and extending to the ventral margin which it meets a little in front of the middle; surface of valve marked by numerous, close-set, somewhat irregular concentric costae, a single costa varying greatly in strength as it crosses the shell giving a finely rugose appearance to the surface and bearing eight or ten radiating costae on and above the umbonal ridge which are more pronounced posteriorly than near the beak.

Dimensions of type specimen, a right valve, are: width, probably about 15 mm.; height, 5.5 mm.; length of hinge-line, 14.3 mm.; convexity of valve, about 4 mm.

Remarks. Although only a single not quite complete representative of this species has been found in the Morrow collections, its characters are so distinctive and so well displayed that there is no hesitancy in describing it as a new species. It is distinguished from the other members of the genus by its extreme convexity, its surface markings, and the comparatively strong umbonal constriction. It is possible that the apparent depth of this sinus in the holotype is slightly increased by crushing of the valve in that region.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135).

Parrallelodon cancellosus n. sp.

Plate XV, figure 7.

Description. Shell small, transversely sub-trapezoidal in outline, very inequilateral, not quite twice as wide as high, hinge-line shorter than greatest width of valve below, valves moderately convex; cardinal line and ventral margin nearly straight

and parallel, anterior margin sub-perpendicular to cardinal line, meeting it in a right angle but rounding into the ventral margin below; posterior margin oblique, joining the hinge-line at an obtuse angle and curving narrowly into the ventral margin; beak inconspicuous, situated nearer the anterior extremity than the middle of the hinge-line; umbonal region somewhat flattened toward the middle of the valve; umbonal ridge rounded and poorly defined, the posterior portion of the valve above the ridge moderately flattened; surface of valve cancellated by fine, close-set, concentric and radiating striae, the radiate markings slightly the stronger over the posterior half of the shell while the concentric lines are the stronger over the anterior portion.

Dimensions of the type specimen, a right valve, are: width, 7.4 mm.; height, 4.0 mm.; length of hinge-line, 5.6 mm.; convexity of valve, about 1.5 mm.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Choteau, Oklahoma (Station 306).

Genus CYPRICARDINIA Hall

Cypricardinia laevicula n. sp.

Plate XV, figure 20.

Description. Shell small, very inequilateral, transversely subellipsodial, about twice as wide as high, hinge-line about two-thirds as long as the greatest width below and rounding gracefully into the oblique ventral margin at the posterior extremity, making the posterior portion of the valve moderately compressed vertically; anteriorly there is a distinct lobate extension of the shell in front of the umbonal elevation, and the ventral margin curves broadly upward into the convex anterior outline which becomes distinctly concave close to the beak; beak situated at the anterior extremity of the hinge-line, umbo tumid, surface of shell sloping somewhat abruptly toward the anterior and more gently toward the posterior extremities, convexity of valve greater near cardinal than near ventral margins; a faint constriction originates on the umbo and passing obliquely across the valve meets the ventral margin a little in front of the middle; surface of shell ornamented by very faint, concentric undulations which may also be observed on the surface of the internal cast.

Dimensions of type specimen, a left valve, are: height, 6.2 mm.; width, 12.5 mm.; length of hinge-line, 8.4 mm.; convexity of valve, about 2.5 mm.

Remarks. This species is based upon a single specimen, a left valve from the Brentwood limestone. It can hardly be other than a *Cypricardinia* although its outlines are quite distinct from those of *C. carbonia,* the only Pennsylvanian member of the genus which is commonly found in the Mississippi valley. The smoothness of the surface of the valve at hand is possibly in part the result of its weathered condition and it may prove that the concentric markings are lamellose and cancellated as is the case in many species of this genus.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135).

PTERIIDÆ

Genus MONOPTERIA Meek

Monopteria? sp.

Plate XV, figure 9.

Two fragments of left valves seem to resemble closely the forms which have been grouped in the genus *Monopteria* although they cannot be referred to it with certainty. The umbonal ridge is fairly strong and very oblique, approaching the hinge-line at an angle of 25° or 30°. The hinge-line is much produced posteriorly and, as restored from the growth lines, probably projected farther than the posterior portion of the shell below. The material at hand does not warrant drawing any conclusions as to affinities with the described species of the genus.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Morrow formation: southeast of Ft. Gibson, Oklahoma (Station 303).

Genus PSEUDOMONOTIS Beyrich

Pseudomonotis precursor n. sp.

Plate XV, figures 1, 1a.

Description. Shell small, inequivalve, irregularly sub-ovate in outline, higher than long, hinge-line half as long as greatest

length of shell, left valve convex, right valve concave. Dimensions of the holotype are: length, 12.5 mm.; height, 13.2 mm.; convexity of left valve, about 3.2 mm.; length of hinge-line, 6.0 mm.

Left valve moderately inflated, convexity strong in umbonal region and near the ventral margin, more gentle throughout the central portion of the valve; beak prominent, narrow, and directed almost vertically; auriculations comparatively small and poorly defined, hinge-line extended about twice as far anteriorly as posteriorly, outline of anterior ear somewhat geniculate; surface of shell ornamented by radiating striae and marked by concentric lines of growth, striae obsolete over umbonal region, originating on the ears and a little above the middle of the valve as fine, somewhat wavy threads elevated above a flat floor and continuing to the margins, increasing slightly in strength and with a few new threads arising by implantation; at intervals near the margins appearing somewhat nodose; lines of growth consisting of slight, irregular elevations about as prominent in the umbonal region as below.

Right valve gently and regularly concave with ornamentation probably similar to that of the left valve.

Remarks. This species is based upon two specimens from the Brentwood limestone, one of which is nearly complete. The right valve is missing in one specimen and somewhat obscured in the other but the generic position of the form is unmistakable. The peculiar ornamentation, with the umbo devoid of sculpture, and the small size of the shell—the type specimen is an adult—serve to readily distinguish it from the other Carboniferous members of the genus.

Horizon and locality. Brentwood limestone: northeast of Fayetteville, Arkansas (Station 135).

Pseudomonotis inflata n. sp.

Plate XV, figures 15, 15a.

Description. Shell large, irregularly sub-circular in outline, length and height sub-equal, greatest length along a line which converges notably toward the hinge-line anteriorly, hinge about half as long as length below, left valve strongly inflated. Dimensions of the holotype are: greatest length, 35.7 mm.; height

perpendicular to hinge-line, 35.4 mm.; convexity of left valve, about 12.5 mm.; length of hinge-line, 16.5 mm.

Left valve strongly but irregularly convex, the greatest inflation occurring at a point a little below the umbo and in front of the middle, surface of the valve curving very abruptly to the anterior lateral margin and toward the auriculations but more gently toward the ventral and posterior margins; ears small and poorly defined, outline of valve very slightly notched beneath anterior ear but not beneath posterior one; beak small but full, situated back of the middle of the hinge-line and directed somewhat posteriorly; margins of the valve probably irregular and somewhat variable, in type specimen posterio-ventral margin slightly concave and posterior margin produced and strongly convex; surface of internal cast ornamented by strong, irregular, rounded, radiating ribs originating beyond the umbo and increasing in strength toward the margin, which display a tendency toward becoming nodose and are crossed by faint, irregular, concentric lines of growth.

Right valve and ornamentation of shell surface unknown.

Remarks. This species is based upon an internal cast of a left valve from the Kessler limestone and differs markedly from the members of this genus described from the Coal Measures in its greater inflation and peculiar outline.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

MYALINIDÆ

Genus MYALINA De Koninck

Myalina recurvirostris Meek & Worthen

1860. *Myalina recurvirostris.* Meek and Worthen, Proc. Acad. Nat. Sci., Phil., p. 456.
Coal Measures: Near Springfield, Illinois.

1866. *Myalina recurvirostris.* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 344, pl. 26, figs. 9a-c.
Upper Coal Measures: LaSalle, Illinois.

1884. *Myalina recurvirostris.* White, 13th Rep. Geol. Surv. Ind., p. 140, pl. 29, figs. 3, 4.
Upper Coal Measures: Indiana.

1894. *Myalina recurvirostris.* Keyes, Mo. Geol. Surv., vol. 5, p. 117, pl. 45, figs. 1a, b.
Upper Coal Measures.

This common Coal Measures form is represented in the Morrow group by four specimens from the Hale formation, which cannot be distinguished from certain of the variants ordinarily identified as belonging to this species. The characteristic curvature of the cardinal portion of the umbonal ridge, the slight flattening and extension of the shell in front of the umbo above the middle, and the concentric lamellose markings of the surface are well shown. The umbonal ridge is, perhaps, not so sharply elevated as in the more typical specimens but this and other minor variations in the contour of the valves are presumably to be explained by the stunted growth of the Morrow forms, none of which attained more than 30 mm. in its longest diameter.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Myalina cuneiformis Gurley?

Plate XV, figure 3.

1883. *Myalina cuneiformis.* Gurley, New Carb. Foss., Bull. No. 1, p. 4.
Upper Carboniferous: Ouray, Colorado.

1903. *Myalina cuneiformis.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 420, pl. 8, figs. 14-17.
Carboniferous beds: Ouray, Colorado.
Weber limestone: Crested Butte district, Colorado.

An internal cast of a *Myalina* from the Kessler limestone resembles so closely the type and other specimens of *M. cuneiformis* that it does not seem practicable to differentiate it from that species. The Kessler valve displays the same cuneate outline approaching a triangular form as do the Colorado shells. The umbonal ridge is even more sharply elevated than in the type material and the umbonal slopes are correspondingly steeper. The angle between cardinal and anterior margins is a very acute one and the former is not sharply differentiated from the posterior margin into which it curves below. The umbonal ridge in the ventral portion of the valve maintains its position close to the anterior margin with the anterior slope of the valve surface much more abrupt than the posterior slope. The material at hand represents a smaller form than is common for this species but a stunted growth seems to be characteristic of many of the Morrow pelecypods. Its dimensions are:

greatest diameter, from beak to ventral margin, 10.7 mm.; breadth, normal to umbonal ridge, 5.3 mm.; length of hinge-line, 5.3 mm.; convexity of valve, about 2.5 mm.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Myalina orthonota n. sp.

Plate XV, figure 4.

Description. Shell of medium size, sub-oval in outline, very inequilateral; hinge-line comparatively short, little over one-third as long as greatest diameter of shell, that from beak to posterio-ventral extremity; anterior and cardinal margins converging at an angle of about 50°, anterior margin nearly straight, posterior margin gently convex, the two approximately parallel throughout the middle half of the shell and rounding gracefully and sub-equally into the strongly convex ventral margin; the umbonal ridge nearly straight with only a slight forward curvature very close to the beak, strongly elevated above with steep umbonal slopes on either side, less prominent below where it merges with the curvature of the valve; valve not produced in front of the umbo, the umbonal slope in front continuing with scarcely lessened declivity to the line of union between the valves; surface marked by close-set, lamellose, concentric, growth lines.

The dimensions of the holotype are: greatest diameter, from beak to posterio-ventral extremity, 16.2 mm.; length of hinge-line, 6.5 mm.; breadth, normal to umbonal ridge, 7.6 mm.; convexity of valve, about 3.5 mm.

Remarks. This species is characterized by its comparatively straight umbonal ridge and anterior margin as well as by its proportionately long diameter from beak to opposite extremity. Its nearest affinities are *M. pernaformis* and *M. perattenuata*, from which it may be distinguished by the characteristics just mentioned. In the Hale formation all the individuals are, as well, comparatively small, the largest having an oblique diameter of only 26 mm., but in the Kessler limestone is a much larger form, only one specimen of which is at hand, which is questionably referred to the same species. The umbonal portion of this individual is missing and it is not possible to identify it with

certainty. Its oblique diameter must have been as great as 55 mm.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 137, and 149). Morrow formation: near Choteau, Oklahoma (Station 306). Kessler limestone: near Brentwood, Arkansas (Station 144).

TRIGONIIDÆ

Genus SCHIZODUS King

Schizodus morrowensis n. sp.

Plate XV, figure 14.

Description. Shell of medium size, transversely sub-ellipsoidal, very inequilateral, length to height about as five to four; posterio-dorsal margin convex, produced posteriorly, rounding narrowly into ventral margin; ventral margin gently convex, rounding broadly into the convex anterio-dorsal margin; left valve gibbous, the surface sloping from the umbo abruptly toward the cardinal and anterior margins, more gently toward the ventral and posterior regions; beak full and prominent, elevated and incurved above the hinge area, situated in front of the middle and directed somewhat obliquely forward; surface of shell smooth except for fine concentric lines of growth. Dimensions of type specimen, a left valve, are: length, 25.5 mm.; height, 19.5 mm.; convexity of valve, about 7.0 mm. Cardinal and internal characters not known.

Remarks. This species is founded upon a left valve preserved as an internal cast with a portion of the shell adhering anteriorly. It differs so notably in outline from the described species of this genus that it cannot be included in any of them.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

PECTINIDÆ

Genus AVICULOPECTEN MacCoy

Aviculopecten hertzeri Meek

Plate XV, figure 11.

1871. *Aviculopecten (Streblopteria ?) hertzeri.* Meek, Proc. Acad. Nat. Sci., Phil., p. 61.
Lower Coal Measures: Newark, Ohio.

1875. *Aviculopecten (Streblopteria ?) hertzeri.* Meek, Pal. Ohio, vol. 2, p. 330, pl. 19, figs. 13a-c.
Lower Coal Measures: Newark, Ohio.

1887. *Aviculopecten hertzeri.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 25, pl. 1, figs. 5, 10.
Coal Measures: Flint Ridge, Ohio.

1900. *Aviculopecten hertzeri.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 121, pl. 13, figs. 8, 1, 1b.
Upper Coal Measures: Topeka, Kansas.

1911. *Aviculopecten hertzeri.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 312, pl. 10, fig. 3.
Mercer limestone: Somerset, Ohio.

Only one specimen of this form has been found in the formations of the Morrow group and it is incomplete in the cardinal region; it is referred with confidence to this species on account of its distinctive shape and surface markings.

Horizon and locality. Kessler limestone: near Brentwood, Arkansas (Station 144).

Aviculopecten talboti Worthen ?

1884. *Aviculopecten talboti.* Worthen, Bull. No. 2, Ill. State Mus. Nat. Hist., p. 21.
St. Louis limestone (oolite beds): Monroe County, Illinois.

1890. *Aviculopecten talboti.* Worthen, Geol. Surv. Ill., vol. 8, p. 114, pl. 22, figs. 11, 11a.
St. Louis limestone (oolite beds): Monroe County, Illinois.

A single left valve, nearly perfect, from the Hale formation corresponds exactly with Worthen's descriptions and figures of this species but when compared with other material from the Monroe County locality minor variations may be noted. The hinge-line is proportionately slightly shorter in the Arkansas form, while the Illinois specimens are longer than high and have somewhat stronger surface markings.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Aviculopecten halensis n. sp.

Plate XV, figure 17.

Description. Shell small, sub-oval in outline exclusive of the ears, length a little greater than height, hinge-line somewhat shorter than length of valve below, ears comparatively large and well-defined; left valve moderately convex, ears defined by

a strong sinus on each side of the beak, that in front being deeper than that behind, anterior ear separated from outline of valve below by a deep byssal sinus, ear extended anteriorly nearly or quite as far as is the margin of the valve below, outline of ear meeting cardinal margin in an acute angle, posterior ear much smaller than that in front; beak somewhat flattened, elevated above anterior ear more sharply than above posterior ear, situated a little behind the middle and directed nearly vertically; surface of valve ornamented by about 25 fine, slightly wavy, radiating costae separated by flat striations about twice their width and crossed by fine, close-set, somewhat irregular lirae, alternate costae dying out at various distances above the margin, the others continuing to the beak; surface of anterior ear ornamented by similar costae, about 4 in number, and concentric lirae, both being somewhat stronger there than on the surface of the valve, the sinus between the ear and umbo being devoid of radiating costae but crossed by the concentric lines which are there incurved upward to maintain their parallel position with respect to the outline of the shell. Dimensions of the type specimen are: length, 6.7 mm.; height, 6.0 mm.; convexity of valve, about 1.5 mm.; length of hinge-line, about 5.5 mm.

Remarks. In a general way this species resembles *A. coxanus* and *A. germanus* but is obviously distinct from them. Its valves are thin and fragile and no perfect specimen has been found, the most complete being preserved as an external mold.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Aviculopecten aurisculptus n. sp.

Plate XV, figure 12.

Description. Shell below medium size, sub-ovate in outline disregarding the ears, length and height sub-equal, hinge-line shorter than greatest length of valve which is found at one-third the distance from ventral margin to beak; left valve moderately convex, the surface sloping abruptly from umbo to auriculations and more gently toward the ventral margin which meets the anterior margin in a broad curve, byssal sinus shallow and broad; anterior ear triangular, well-defined and somewhat

extended though not so much so as valve below, posterior margin and ear not known, but that ear is probably smaller than the one in front; beak prominent and somewhat elevated, directed forward with only a very slight obliquity; surface of anterior ear sculptured by about 9 radiating striae, coarser and somewhat nodose above and becoming finer and smoother below, crossed by very fine, close-set, concentric growth lines, both striae and growth lines continuing on the surface of the valve below the ear but becoming gradually fainter so that to the unaided eye the valve appears to be nearly smooth except adjacent to the anterior margin; the growth lines may be traced with the aid of a lens over the whole surface so far as known but the radiating striae which near the ear originate at the beak, become shorter as well as fainter as followed across the surface toward the ventral margin, the shortening being due to the more marginal origination of each successive striation, until they become obsolete at about the middle point of the valve.

The dimensions of the holotype are: length, ±11 mm.; height, ±13 mm.; convexity of left valve, about 3 mm.; length of hinge-line, ±7.5 mm.

Remarks. This species is founded upon a single, imperfectly preserved left valve, but its surface markings are so distinctive as to differentiate it clearly from other members of this or allied genera. In the absence of the right valve and information concerning its internal characters it is referred provisionally to *Aviculopecten* although it may prove to be a *Deltopecten* when better known.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Aviculopecten? cf. **interlineatus** Meek & Worthen.

Several fragments of an *Aviculopecten* or *Deltopecten* from the locality noted below represent a form closely allied to *A.? interlineatus*. The shells are small, with poorly defined auriculations and with length of hinge-line only a little less than the greatest length of the valve below and at right angles to axis of valve; the ventral margin is regularly convex and curves equally to the anterior and posterior lateral margins which

are convex until just below the ears where they are more or less concave, the auriculations being sub-equal but somewhat variable in outline in different individuals; the surface ornamentations consist of concentric costae, six or eight in number, with concentric striae occupying the space between them, about six to eight striae between each two costae; the markings are more closely spaced near the ears and spread out below, are much fainter on the umbo than toward the margins, and in crossing the ears are bent outward. The concentric costae are not nearly so prominent nor so numerous as those in the typical *A.? interlineatus.*

Horizon and locality. Brentwood limestone: northeast of Fayetteville, Arkansas (Station 135).

Aviculopecten arkansanus n. sp.

Plate XV, figure 13.

Description. Shell small, obliquely sub-oval in outline exclusive of the ears, length and height sub-equal, hinge-line about three-fourths as long as greatest length of valve below, the latter being along a line which if produced would meet the hinge-line 15 mm. or so in front of the beak; left valve convex, the beak full and separated from the auriculations by a sinus on either side, that in front being the stronger of the two which converge upward at an angle of about 65°, the beak directed obliquely forward and extending slightly beyond the hinge-line; ears comparatively large and sub-equal, each separated from the margins of the valve below by a byssal sinus, that in front deep and strongly concave, the posterior one shallow and gently concave, outline of anterior ear rounding narrowly to the cardinal margin while that of posterior ear meets the hinge-line in an acute angle; surface of valve ornamented by about 15 fine, radiating, ridge-like costae separated by flat striations about three times their width, in the center of which near the ventral margin faint intermediate costae may sometimes be detected, concentric lines not apparent in the material at hand, auriculations unsculptored except for a single, faint, broad, undefined radial depression across the anterior ear.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Aviculopecten sp.

Plate XV, figure 16.

From the same locality in the Kessler limestone as that which furnished the species just described was obtained an internal cast of a shell with the same general shape but differing from it in important details. The hinge-line is proportionately shorter, the ears smaller, the beak converging upward less acutely, and the whole valve less convex. The external ornamentations of this form are unfortunately not known and the internal cast is smooth except for faint concentric growth lines and a suggestion of radiating striae. It is probably a cast of another undescribed *Aviculopecten.*

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Genus DELTOPECTEN Etheridge

Deltopecten occidentalis (Shumard)

1855. *Pecten occidentalis.* Shumard, 1st and 2nd Repts. Geol. Surv. Mo., p. 207, pl. C, fig. 18.
Coal Measures: Near Plattsburg, Clinton County, Missouri.

1858. *Pecten Cleavelandicus.* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 184.
Permian: Valley of South Cottonwood, Kansas.

1861. *Pecten occidentalis.* Newberry, Ives's Colo. Expl. Exped., p. 128.
Coal Measures: Banks of the Stranger, above Easton, Kansas.

1864. *Aviculopecten* ——————?. Meek and Hayden, Pal. Upper Mo., p. 50, pl. 2, fig. 10.
Permian: Near Chapman's Creek, 18 miles above Ft. Riley, Kansas.

1866. *Aviculopecten occidentalis.* Meek and Worthen, Geol. Surv. Ill., vol. 2, p. 331, pl. 27, figs. 4-5a.
Upper Coal Measures: Saline Creek, Gallatin County, Illinois.

1866. *Pecten Missouriensis ?.* Geinitz, Carb. und Dyas in Nebr., p. 35, tab. 2, fig. 18.
Nebraska City, Nebraska.

1872. *Aviculopecten occidentalis.* Meek, U. S. Geol. Surv. Nebr., p. 191, pl. 9, fig. 10.
Upper Coal Measures: Rock Bluff, Bennett's Mill, Wyoming, and Nebraska City, Nebraska; Illinois; Missouri; Iowa; Kansas; Kentucky.
Coal Measures: Black Hills, Dakota.

1876. *Aviculopecten occidentalis.* White, Powell's Rep. Geol. Uinta Mts., p. 90.
Lower Aubrey group: Two miles above Belleview, Utah.

1877. *Aviculopecten occidentalis.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 146, pl. 12, figs. 8a-b.
Carboniferous: Camp Apache, Arizona.

1884. *Aviculopecten occidentalis.* White, 13th Rep. Geol. Surv. Ind., p. 143, pl. 28, fig. 2.
Coal Measures: Pike and Gibson Counties, Indiana.

1886. *Aviculopecten occidentalis.* Heilprin, 2nd Geol. Surv. Penn., Ann. Rep. for 1885, p. 455, fig. 5a; p. 442, fig. 5.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1886. *Aviculopecten occidentalis.* Heilprin, Proc. and Coll. Wyo. Hist. and Geol. Soc., vol. 2, pt. 2, p. 270, fig. 5; p. 271, fig. 5a.
Mill Creek limestone, Upper Coal Measures: Wilkesbarre, Pennsylvania.

1891. *Aviculopecten occidentalis.* White, Bull. U. S. Geol. Surv., No. 77, p. 29, pl. 4, fig. 1.
Permian: Military Crossing, Baylor County, Texas.

1894. *Aviculopecten occidentalis.* Keyes, Mo. Geol. Surv., vol. 5, p. 110, pl. 42, fig. 3.
Upper Coal Measures: Plattsburg, and Kansas City, Missouri.

1897. *Aviculopecten occidentalis.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 34.
Lower Coal Measures: Conway County, Arkansas.

1899. *Aviculopecten occidentalis.* Girty, 19th Ann. Rep. U. S. Geol. Surv., pt. 3, p. 578.
Upper Coal Measures: McAlester and Atoka quadrangles, Indian Territory.

1900. *Aviculopecten occidentalis.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 114, pl. 13, fig. 7.
Upper Coal Measures: Turner, Eudora, Lawrence, Topeka, and Wabaunsee County, Kansas.

1902. *Aviculopecten occidentalis.* Beede, Adv. Bull. of 1st Bienn. Rep. Geol. Surv. Okla., p. 9, pl. 1, fig. 5.
Red Beds: White Horse Springs, Oklahoma.

1903. *Aviculopecten occidentalis.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 414, pl. 8, fig. 1.
Middle portion of Hermosa formation: San Juan region, Colorado.
Rico formation: San Juan region, Colorado.
Maroon formation: Crested Butte district, Colorado.

1909. *Deltopecten occidentalis.* Girty, Bull. U. S. Geol Surv., No. 389, p. 84.
Manzano group, Abo sandstone: Abo Canyon, New Mexico.

1911. *Aviculopecten occidentalis.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 312, pl. 10, fig. 2.
Mercer limestone: Bald Knob, Ohio.

1914. *Deltopecten occidentalis.* Price, West Va. Geol. Surv., Preston County Rep., p. 525.

Ames limestone: Portland district, east side of Cheat River, 0.6 mile east of Trowbridge, near head of ravine; Reno district, 0.5 mile northwest and 2.6 miles east of Fellowsville.

Pine Creek limestone: Grant district, 0.8 mile south of Brandonville.

Brush Creek limestone: Grant district, 2.1 miles north of Hopewell Church, 1.2 miles southeast of Brandonville, and 0.9 mile northeast of Bruceton Mills; Vallet district, 2.1 miles east of Reedsville.

A number of fragmentary specimens from the localities noted below seem to belong to this common Pennsylvanian species which has been frequently observed in the Mississippi valley. They are smaller than the majority of the forms thus referred as the material at hand represents shells which could not have been longer than 12 to 15 mm. Yet the outlines of the auriculations and the ornamentation of the surface seem identical with those of the typical forms.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

LIMIDÆ

Genus PALAEOLIMA Hind

Palaeolima inequicostata n. sp.

Plate XV, figure 18.

Description. Shell below medium size, transversely oblique, sub-oval in outline, length (along a line which if extended would intercept the hinge-line about 12 mm. in front of the beak) greater than height, hinge-line two-fifths as long as greatest length; posterio-dorsal margin nearly straight, oblique, meeting the ventral margin in a broad curve; ventral margin convex, probably somewhat truncated in front; left valve moderately gibbose, surface sloping abruptly from the umbo toward the auriculations and more gently toward the ventral margin; ears small, triangular, depressed, beak situated behind the middle, its sides converging at an angle of about 90°; surface of internal cast ornamented by radiating, angular costae separated by rounded striae, the posterior costae being the stronger and

growing successively fainter anteriorly until over the extreme anterior portion of the valve radiating lines cannot be observed, ears and adjacent umbonal slopes smooth.

Dimensions of the type specimen are: length, 13.5 mm.; height, 11.0 mm.; convexity of valve, about 3.0 mm.; hinge-line, 5.6 mm.

Remarks. This internal cast of a left valve from the Kessler limestone bears such close resemblance in shape to the shells which Hind has grouped under the name *Palaeolima* that it is provisionally placed in that genus. The species resembles most closely *P. obliquiradiata* but is obviously distinct from it.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

PLEUROPHORIDÆ

Genus PLEUROPHORUS King

Pleurophorus tropidophorus Meek

1875. *Pleurophorus tropidophorus.* Meek, Pal. Ohio, vol. 2, p. 338, pl. 19, figs. 10a-b.
Coal Measures: Newark, Ohio.

1887. *Pleurophorus tropidophorus.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 35, pl. 4, fig. 15.
Coal Measures: Flint Ridge, Ohio.

1900. *Pleurophorus tropidophorus.* Beede, Univ. Geol. Surv. Kans., vol. 6, p. 162, pl. 20, fig. 7.
Upper Coal Measures: Kansas City, Missouri.

1911. *Pleurophorus tropidophorus.* Mark, Bull. Sci. Lab. Den. Univ., vol. 16, p. 312, pl. 10, fig. 11.
Mercer limestone: Limestone Hollow, Flint Ridge, Ohio.

This species is represented in the material at hand by a single specimen of a right valve from which the anterior third is missing. The outline, umbonal ridges, and surface markings conform so closely to Meek's description and figures that the reference to his species is made with considerable confidence.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

GASTROPODA

ACMAEIDÆ

Genus LEPETOPSIS Whitfield

Lepetopsis chesterensis Worthen ?

1884. *Lepetopsis chesterensis.* Worthen, Bull. Ill. State Mus. Nat. Hist., No. 2, p. 25.
Lower Chester limestone: Chester, Illinois.

1890. *Lepetopsis chesterensis.* Worthen, Geol. Surv. Ill., vol. 8, p. 140, pl. 25, figs. 1-1a.
Chester limestone: Chester, Illinois.

A single specimen from the Hale formation, although somewhat imperfect, appears to be referable to this species. In ratio of length to breadth, position of apex, and surface markings, its characters, so far as known from the material at hand, agree perfectly with Worthen's figures and descriptions. The portion of the shell which ought to bear the gentle sinus behind the apex is, however, missing.

The dimensions of the specimen, as restored, would be: length, 14 mm.; width, 11 mm.; height, 6 mm.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137).

Lepetopsis sp.

Plate XVI, figures 5, 5a.

Another gastropod shell, somewhat larger than the foregoing one, is also referred to the genus *Lepetopsis.* The width is about two-thirds the length and the aperture is regularly elliptical; the apex is situated nearer to the margin than to the midlength of the shell and the posterior slope is distinctly concave. The surface markings are unknown. The dimensions of the only specimen at hand are: length, 19.5 mm.; width, 13 mm.; height, 5.5 mm.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

BELLEROPHONTIDÆ

Genus BELLEROPHON Montfort

Bellerophon crassus var. **wewokanus** Girty

Plate XVI, figures 3, 3a.

1911. *Bellerophon crassus* var. *wewokanus.* Girty, Ann. N. Y. Acad. Sci., vol. 21, p. 138.
Wewoka formation: Wewoka and Coalgate quadrangles, Oklahoma.

1914. *Bellerophon crassus* var. *wewokanus.* Price, West Va. Geol. Surv., Preston County Rep., p. 532.
Ames limestone: Portland district, 0.6 mile east of Trowbridge; Reno district, 0.5 mile northwest of Fellowsville.
Brush Creek limestone: Garrett County, Maryland, B. & O. R. R. cut at Hutton.

Two specimens from the Brentwood limestone are referred with confidence to this variety. They display the general shape and appearance of typical *B. crassus* but are rather undersized for members of that species and in both instances the umbilicus is solidly closed.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 134).

Bellerophon cf. **sublaevis** Hall

Plate XVI, figures 4, 4a.

A number of small Bellerophons seem to resemble rather closely Hall's species and are included under this title. The shell surface, in the few instances where it is preserved, is perfectly smooth, but although two or three individuals present a shape closely approximating that of the Mississippian shells the majority appear to be narrower and more slender with a more flaring aperture. The material at hand, however, is so poorly preserved and incomplete that it seems unwise to erect a new species for its reception.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Wagoner (Station 294), and Choteau (Stations 302 and 307), Oklahoma.

Genus EUPHEMUS McCoy

Euphemus carbonarius (Cox)

1855. *Bellerophon Urii.* Norwood and Pratten, Jour. Acad. Nat. Sci., Phil., (2), vol. 3, p. 75, pl. 9, figs. 6a-c. (Not *B. urii* Fleming, 1828.)
   Coal Measures: Galatia and Grayville, Illinois; and 5 miles below New Harmony, Indiana.
1857. *Bellerophon carbonarius.* Cox, Geol. Surv. Ky., vol. 3, p. 562.
   Coal Measures: Kentucky.
1860. *Bellerophon vittatus.* McChesney, Desc. New Pal. Foss., p. 59.
   Coal Measures: Mouth of Rush Creek, Indiana; Graysville, Illinois.
1860. *Bellerophon blaneyanus.* McChesney, Desc. New Pal. Foss., p. 60.
   Coal Measures: Saline and Peoria Counties, and Danville and Graysville, Illinois.
1865. *Bellerophon blaneyanus.* McChesney, Ill. New Spec. Foss., pl. 2, figs. 5a-c.
1866. *Bellerophon carbonarius.* Geinitz, Carb. und Dyas in Nebr., p. 6, tab. 1, fig. 8.
   Upper Carboniferous: Nebraska City, Nebraska.
1868. *Bellerophon Blaneyanus.* McChesney, Trans. Chicago Acad. Sci., vol. 1, p. 45, pl. 2, figs. 5a-c.
   Coal Measures: Saline and Peoria Counties, Illinois; Danville and Graysville, Illinois.
1872. *Bellerophon carbonarius.* Meek, U. S. Geol. Surv. Nebr., p. 224, pl. 4, fig. 16; pl. 11, figs. 11a-c.
   Upper Coal Measures: Nebraska City, Nebraska.
   Coal Measures: Iowa; Kansas; Missouri; Illinois; Kentucky; and Indiana.
   Lower Coal Measures: West Virginia.
1884. *Bellerophon carbonarius.* White, 13th Rep. Geol. Surv. Ind., p. 158, pl. 33, figs. 6-8.
   Coal Measures: Indiana.
1887. *Bellerophon carbonarius.* Herrick, Bull. Sci. Lab. Den. Univ., vol. 2, p. 19, pl. 2, fig. 20.
   Coal Measures: Flint Ridge, Ohio.
1888. *Bellerophon urii.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 235.
   Lower Coal Measures: Des Moines, Iowa.
1891. *Bellerophon urii.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 255.
   Lower Coal Measures: Des Moines, Iowa.
1894. *Bellerophon urii.* Keyes, Mo. Geol. Surv., vol. 5, p. 149, pl. 50, figs. 5a-c.
   Upper Coal Measures: Kansas City, Missouri.
1897. *Bellerophon carbonarius.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 39.
   Lower Coal Measures: Conway County, Arkansas.
1897. *Euphemus (Bellerophon) carbonarius.* Ulrich, Geol. Minn., vol. 3, pt. 2, p. 855.

1899. *Euphemus carbonarius.* Girty, 19th Ann. Rep. U. S. Geol. Surv., pt. 3, p. 592.

1914. *Euphemus carbonarius.* Price, West Va. Geol. Surv., Preston County Rep., p. 533.
Ames limestone: Throughout the county.
Brush Creek limestone: Grant district, 0.7 mile south of Laurel Church, 0.9 mile northeast of Bruceton Mills, Garrett County, Maryland, 4 miles northwest of Oakland, and B. & O. R. R. cut at Hutton.

This species is represented in the Morrow collections by 4 specimens, all more or less incomplete and slightly under the average size of the Coal Measures forms referred to it. In one the shell surface is completely exfoliated but in the others the revolving striae are well shown.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 137). Brentwood limestone: near Fayetteville, Arkansas (Station 135).

PLEUROTOMARIIDÆ

Genus WORTHENIA DeKoninck

Worthenia tabulata (Conrad)

Plate XV, figure 27.

1835. *Turbo tabulata.* Conrad, Trans. Geol. Soc. Penn., vol. 1, pt. 2, p. 267, pl. 12, fig. 1.

1842. *Pleurotomaria tabulata.* Conrad, Jour. Acad. Nat. Sci., Phil., 1st ser., vol. 8, p. 272.
Carboniferous: Inclined plane of the Allegheny Mountains.

1858. *Pleurotomaria tabulata.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 721, pl. 29, figs. 12a-b.
Coal Measures: Pennsylvania; Indiana; and Illinois.

1881. *Pleurotomaria tabulata.* White, 2nd Ann. Rep. Dep. Stat. and Geol. Ind., p. 519, pl. 18, figs. 4-5.
Coal Measures: Rush Creek, Posey County; Wagondefeat Creek, Sullivan County; and Warrick County, Indiana.

1894. *Pleurotomaria tabulata.* Keyes, Mo. Geol. Surv., vol. 5, p. 142.
Upper Coal Measures: Kansas City, Missouri.

1897. *Worthenia tabulata.* Ulrich, Geol. Minn., vol. 3, pt. 2, p. 935.

1903. *Worthenia tabulata ?.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 456.
Top of Hermosa formation: Dolores River region, Sinbad's Valley, Colorado.

1910. *Worthenia tabulata.* Raymond, Ann. Carnegie Mus., vol. 7, p. 157, pl. 26, fig. 2.
Brush Creek limestone: Donohoe, Pennsylvania.

1911. *Worthenia tabulata.* Raymond, Penn. Topog. and Geol. Surv. Comm., Rep. for 1908-10, pl. 5, fig. 2.
Brush Creek limestone: Donohoe, Pennsylvania.

An incomplete external mold from the Kessler limestone is referred to this species with considerable confidence. Portions of eight volutions are represented and in shape, surface markings, and angularity of the whorls, the material at hand corresponds in every particular to the figures and descriptions of the typical members of Conrad's species.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209).

Genus EUCONOSPIRA Ulrich

Euconospira arkansana n. sp.

Plate XV, figure 25.

Description. Shell below medium size, regularly conical in shape, somewhat broader than high, base gently convex; volutions five or six in number, flattened on the upper or visible slope, the last one distinctly angular around the periphery, and slightly convex below; umbilical region gently concave, umbilicus small and probably quite shallow; band narrow, concave, grooved, visible on all the volutions, situated between two sharply elevated lines, the lower one of which forms the periphery of the whorls; aperture not well shown in any of the specimens at hand; surface ornamented by about nine, somewhat irregularly spaced, revolving costae crossed by slightly fainter, more closely spaced, oblique and gently curved, transverse lines which make the costae appear as discontinuous series of small nodes; below the angle the under side of the body whorl bears about twelve fine revolving costae crossed by very faint obscure lines of growth.

Height of an average specimen, 8.5 mm.; breadth, 9.8 mm.; apical angle, 70°.

Remarks. In comparison with *E. turbiniformis* (M. & W.) which shell this form closely resembles in shape, it is characterized by the much smaller size of the adult individuals and the smaller number of revolving costae on each volution.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135). Morrow formation: near Choteau, Oklahoma (Station 302).

EUOMPHALIDÆ

Genus STRAPAROLLUS Montfort

Straparollus cf. spergenensis (Hall)

Plate XVI, figure 9.

1856. *Euomphalus Spergenensis.* Hall, Trans. Albany Inst., vol. 4, p. 19.
St. Louis limestone: Spergen Hill and Bloomington, Indiana.

1882. *Euomphalus Spergenensis.* Whitfield, Bull. Am. Mus. Nat. Hist., vol. 1, p. 69, pl. 8, figs. 16-19.
St. Louis group: Spergen Hill, Paynter's Hill, Bloomington, and Ellettsville, Indiana.

1883. *Euomphalus Spergenensis.* Hall, 12th Rep. Geol. Surv. Ind., p. 350, pl. 31, figs. 16-19.
St. Louis group: Spergen Hill, Lanesville, and Bloomington, Indiana.

1894. *Straparollus spergenensis.* Keyes, Mo. Geol. Surv., vol. 5, p. 159.
St. Louis limestone: St. Louis, Missouri.

1903. *Straparollus* cf. *spergenensis.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 313.
Leadville limestone: Leadville district, Colorado.

1906. *Straparollus spergenensis.* Cummings, 30th Ann. Rep. Geol. Surv. Ind., p. 1337, pl. 25, figs. 16-19.
Salem limestone: Spergen Hill, Paynter's Hill, Bloomington, Ellettsville, Stinesville, and Harrodsburg, Indiana.

From the Morrow formation in one locality were obtained several specimens of a *Straparollus* scarcely distinguishable from the Mississippian form described by Hall. The shells at hand are nearly or quite flat, displaying only a slight tendency toward the development of a spire. In comparison with specimens from Spergen Hill the only difference discernible is the somewhat more rapid expansion of the Morrow individuals in the youthful stages, so that in specimens of the same diameter there are generally one or two more volutions in the typical material than in the forms from Oklahoma.

Horizon and locality. Morrow formation: near Choteau, Oklahoma (Station 302).

Genus EUOMPHALUS Sowerby

Euomphalus catilloides (Conrad)

Plate XV, figure 24.

1842. *Inachus catilloides.* Conrad, Jour. Acad. Nat. Sci., Phil., 1st ser., vol. 8, p. 273, pl. 15, fig. 3.
Carboniferous: Inclined plane of the Allegheny Mountains.

1858. *Euomphalus rugosus.* Hall, Geol. Iowa, vol. 1, pt. 2, p. 722, pl. 29, figs. 14a-c.
Coal Measures: Illinois.

1866. *Serpula (Spirorbis) Planorbites.* Geinitz, Carb. und Dyas in Nebr., p. 3, tab. 1, fig. 6.
Nebraska.

1872. *Straparollus (Euomphalus) rugosus.* Meek, U. S. Geol. Surv. Nebr., p. 230, pl. 6, figs. 5a-b; pl. 11, figs. 4a-b.
Upper Coal Measures: Nebraska City, Rock Bluff, Aspinwall, and Cedar Bluff, Nebraska.
Coal Measures: Kansas; Missouri; Iowa; Illinois.

1873. *Straparollus (Euomphalus) subrugosus.* Meek and Worthen, Geol. Surv. Ill., vol. 5, p. 607, pl. 29, fig. 11.
Coal Measures: Springfield, Illinois.

1874. *Euomphalus rugosus.* Meek, Am. Jour. Sci., 3rd ser., vol. 7, p. 583.

1884. *Euomphalus (Straparollus) subrugosus.* Walcott, Pal. Eureka Dist., p. 255, pl. 18, fig. 19.
Lower Carboniferous: Eureka District, Nevada.

1884. *Euomphalus rugosus.* White, 13th Rep. Geol. Surv. Ind., p. 161, pl. 32, figs. 11, 12.
Coal Measures: Indiana.

1888. *Euomphalus rugosus.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 241.
Lower Coal Measures: Des Moines, Iowa.

1891. *Straparollus catilloides.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 255.
Lower Coal Measures: Des Moines, Iowa.

1894. *Straparollus catilloides.* Keyes, Mo. Geol. Surv., vol. 5, p. 160.
Upper Coal Measures: Kansas City, Missouri; Atchison, Kansas.

1903. *Euomphalus catilloides.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 465.
Middle portion of Hermosa formation: San Juan region, Coloradc.
Top of Hermosa formation: Dolores River region, Sinbad's Valley, Colorado.
Maroon formation: Crested Butte district, Colorado.

1910. *Euomphalus catilloides.* Raymond, Ann. Carnegie Mus., vol. 7, p. 157, pl. 25, fig. 5.
Brush Creek limestone: Donohoe, Pennsylvania.

1911. *Euomphalus catilloides.* Raymond, Penn. Topog. and Geol. Surv. Comm., Rep. for 1908-10, pl. 5, fig. 7.
Brush Creek limestone: Donohoe, Pennsylvania.

1914. *Schizostoma catilloides.* Price, West Va. Geol. Surv., Preston County Rep., p. 537.
Ames limestone: Throughout the county.
Brush Creek limestone: At nearly all the localities examined.

This species is represented from three localities by four specimens, none of which is quite complete. They seem to be in

every respect typical individuals of this form which higher in the Pennsylvanian series becomes much more abundant.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 139). Brentwood limestone: Kessler Mountain, Arkansas (Station 147). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

STROPHOSTYLIDÆ

Genus STROPHOSTYLUS Hall

Strophostylus subovatus (Worthen) ?

Plate XV, figures 23, 23a.

1873. *Naticopsis subovatus.* Worthen, Geol. Surv. Ill., vol. 5, p. 595, pl. 28, fig. 9.
Upper Coal Measures: LaSalle, Illinois.

1898. *Strophostylus subovatus.* Weller, Bull. U. S. Geol. Surv., No. 153, p. 615.

1903. *Strophostylus subovatus ?.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 463, pl. 10, figs. 3-3a.
Middle portion of Hermosa formation: San Juan region, Colorado.

Only one specimen of this form has come to hand. It is much smaller than the typical material and the shell from the Hermosa formation which Girty has referred with a query to this species. With the latter, however, it appears to agree closely in conformation and, although little more than half as large, a reference of the two to the same species seems altogether justifiable. It is possible that this early Pennsylvanian form should be separated specifically, or at least varietally, from the Upper Coal Measures type.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

Genus PLATYCERAS Conrad

Platyceras parvum (Swallow)

Plate XV, figure 28.

1858. *Capulus parvus.* Swallow, Trans. St. Louis Acad. Sci., vol. 1, p. 205.
Coal Measures: Valley of the Verdegris, Kansas.

1872.
pl. 4, figs. 15a-b.
Upper Coal Measures: Three-fourths of a mile west of Nebraska City Landing, Nebraska.
Middle Coal Measures: Illinois.

1877. *Platyceras Nebrascense.* White, U. S. Geog. Surv. west of 100th Merid., vol. 4, p. 159, pl. 12, figs. 5a-d.
Carboniferous: Near Santa Fe, New Mexico.

1884. *Platyceras Nebrascense.* White, 13th Ann. Rep. Geol. Surv. Ind., p. 159, pl. 32, figs. 15,16.
Coal Measures: Eugene, Edwardsport, and New Harmony, Indiana.

1890. *Capulus parvus.* Keyes, Am. Geol., vol. 6, p. 9.

1890. *Capulus parvus.* Keyes, Proc. Acad. Nat. Sci., Phil., p. 177, pl. 2, figs. 14a-c.
Upper Coal Measures: Indiana; Iowa; Nebraska; Kansas; and New Mexico.

1894. *Capulus parvus.* Keyes, Mo. Geol. Surv., vol. 5, p. 180, pl. 54, figs. 5a-b.
Upper Coal Measures: Kansas City, Missouri.

1903. *Platyceras parvum.* Girty, Prof. Paper, U. S. Geol. Surv., No. 16, p. 461, pl. 10, figs. 1-1a, 2-2a.
Lower and upper portions of Hermosa formation: San Juan region, Colorado.

This species is the most characteristic one among the gastropods of the Morrow formations and has been identified from ten localities representing each of the fossiliferous horizons of the group. Considerable variation is displayed in the size and degree of curvature of the different individuals but all are referable to this common Pennsylvanian species. One specimen, in which the shell surface has been well preserved, is marked by numerous crowded and strongly sinuous lines of growth but in most cases the preservation is that of an internal cast.

The half dozen specimens from station 210 are all dwarfed, the largest having a diameter of less than 10 mm. Some of them are evidently mature despite their small size.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 137 and 149). Brentwood limestone: near Fayetteville, Arkansas (Station 135); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Tahlequah (Station 293), Choteau (Stations 295, 302, and 306), and Ft. Gibson (Station 303), Oklahoma.

LOXONEMATIDÆ

Genus ACLISINA De Koninck

Aclisina? sp.

Plate XVI, figures 1, 2.

The presence of high-spired gastropods in the Morrow fauna is indicated by several internal casts, nearly all of which are fragmentary, and one very poorly preserved specimen which displays the surface markings. The latter consist of about six revolving carinae upon each volution; transverse markings are apparently not present. The dimensions of the most complete of the internal casts, a shell composed of six volutions, are as follows: height, 17 mm.; diameter of last volution, 7 mm.; height of last volution, 5 mm.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136). Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Wagoner, Oklahoma (Station 294).

SUBULITIDÆ

Genus MEEKOSPIRA Ulrich

Meekospira? sp.

Plate XVI, figure 6.

Two specimens of a small medium-spired gastropod are included under this title. The shell is composed of about six whorls, the last of which comprises nearly one-half the length of the shell and is gently convex in outline. The apical angle is 35° and the slopes of the spire are straight; the sutures are well-defined although all but the last of the volutions are quite flat. Surface markings are not apparent and the lower portion of the aperture is missing.

The form is referred to *Meekospira* with some doubt as it may be a *Bulimorpha.* Of described species of these genera it most closely resembles *M. inornata* (Meek and Worthen) but is smaller and more slender than that species.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Ft. Gibson, Oklahoma (Station 301).

Genus SPHAERODOMA Keyes

Sphaerodoma sp.

Plate XV, figure 26.

This species, represented by two very imperfect specimens, is referred with considerable confidence to *Sphaerodoma* although its specific relations cannot be determined from the material at hand. In general, it resembles *S. medialis* (Meek and Worthen) but is only about half the size of the figured type of that species. From the description of one of the Manzano specimens described by Girty[55] as *S.* aff. *medialis* it would appear that a close resemblance must exist between that form and the Morrow individuals.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Choteau, Oklahoma (Station 302).

CEPHALOPODA

ORTHOCERATIDÆ

Genus ORTHOCERAS Breynius

Orthoceras sp.

Plate XVI, figures 7, 8.

Description. Shell slender, straight, without annulations or longitudinal ridges, circular in cross-section, tapering comparatively rapidly, one specimen enlarging from a diameter of 2.3 mm. to one of 4.4 mm. in the space of 15 mm.; septa simple, concave, 4 or 4½ occuring in the length of one diameter; siphuncle near, but apparently never at, the center, small, its diameter equal to about one-eighth that of the shell; surface devoid of ornamentation in the material at hand.

Remarks. Fragments of several individuals of this species are in the Morrow collections and represent forms ranging in diameter from 1.7 mm. to 13 mm. In none is there any deviation from the circular cross-section nor any evidence of surface markings though the preservation is such in many cases as to retain what is believed to be the shell surface.

This is probably the form which has been variously identified as *O. okawense* or *O. rushense*, but it is impossible from the published figures and descriptions to confirm the suspicion that

the forms to which those names have been given are conspecific with each other and with the material at hand. The reference to *Orthoceras* is believed to be correct, in spite of the rapid enlargement of the shell, because of the small siphuncle and smooth surface. The type of *Geisonoceras, G. rivale* (Barrande), is characterized by a large siphuncle and banded surface markings.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Station 135). Morrow formation: near Ft. Gibson, Oklahoma (Station 303).

GLYPHIOCERATIDÆ

Genus GASTRIOCERAS Hyatt

Gastrioceras branneri Smith

Plate XVI, figures 12, 12a.

1896. *Gastrioceras branneri.* Smith, Proc. Am. Phil. Soc., vol. 35, p. 257, pl. 23, figs. 1-6. Reprinted 1897 as Cont. No. 9, Hopkins Seaside Labor., Leland Stanford Univ. with changed pagination (257=47).

Lower Coal Measures: Pilot Mountain, Carroll County, Arkansas.

1903. *Gastrioceras branneri.* Smith, Mon., U. S. Geol. Surv., No. 42, p. 83, pl. 11, figs. 8-13.

Chester group, Lower Carboniferous: Pilot Mountain, Carroll County, Arkansas.

1914. *Gastrioceras branneri.* Smith, Leland Stanford Univ., Publication, Acceleration of Development in Fossil Cephalopoda, pl. 1, figs. 12-14.

Two specimens of this species, described some years ago by Dr. Smith from the Morrow horizon in Carroll County, are in the collections at hand. One is a small fragment while the other is a more nearly complete shell. The latter, in comparison with the figures of the type specimen, appears to be slightly more flattened on the venter but in all other respects is identical.

Horizon and locality. Hale formation, East Mountain, Fayetteville, Arkansas (Station 149). Morrow formation: near Ft. Gibson, Oklahoma (Station 296).

Gastrioceras kesslerense n. sp.

Plate XVI, figures 10-10b.

Description. Shell of medium size, discoidal, with whorls slowly increasing in size, depressed semi-circular in cross-

section and deeply embracing, indented to nearly half their height by the preceding whorls; height of whorl about two-thirds its breadth and about two-fifths the total diameter of the shell; umbilicus comparatively wide; surface of the shell not marked by ribs, but with rounded constrictions crossing the venter and lateral slopes in the mature portion of the shell, about five constrictions in a volution.

DIMENSIONS.

Diameter	23.9 mm.
Height of last whorl	9.5 mm.
Width of umbilicus	8.4 mm.
Breadth	12.3 mm.
Height of last whorl from top of preceding	5.2 mm.
The specimen shows about five whorls at the diameter of	23.9 mm.

The sutures consist of three pairs of external lobes and as many saddles; the siphonal lobes are long, narrow, and pointed; first lateral pair broader and slightly pointed, and on the umbilical shoulder is a very shallow, broadly V-shaped lobe; siphonal saddle narrow, indented at the end; first lateral saddle nearly twice as high and broadly rounded; second lateral saddle not so high as first and more narrowly rounded. The inner lobes are three in number: a long, narrow, pointed, antisiphonal lobe with a shorter lobe of about the same shape on either side; the four internal saddles are rounded, the lateral ones very broad and the mesial pair quite narrow.

Horizon and locality. Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Choteau, Oklahoma (Station 302).

Gastrioceras pygmaeum n. sp.

Plate XVI, figures 11-11b.

Description. Shell small, discoidal to sub-globose, moderately involute, whorls semi-lunular in cross-section and deeply embracing, indented to nearly half their height by the preceding whorls; breadth of whorl nearly one-fourth greater than its height and equal to about one-half the diameter of the shell; umbilicus comparatively large, its width slightly greater than one-third the diameter of the shell; surface bearing numerous faint ribs confined to the rounded umbilical shoulder and obso-

lete in many specimens; constrictions present on many individuals with about 5½ to a volution, rounded and faint; venter smooth except for constrictions.

The sutures so far as known, only the external lobes and saddles being observable, are of the typical *Gastrioceras* type.

DIMENSIONS OF TWO INDIVIDUALS.

Diameter	5.2 mm.	5.0 mm.
Height of last whorl	2.3 mm.	1.9 mm.
Width of umbilicus	1.6 mm.	1.3 mm.
Breadth	2.8 mm.	2.6 mm.
Height of last whorl above surface of next preceding	1.1 mm.	1.2 mm.

Remarks. That these little shells represent mature individuals is apparent from the fact that over a dozen of them, all approximately the same size, are at hand and none of them are associated with ammonoids of a large size. The presence of the constrictions and umbilical ribs is also indicative of maturity.

Horizon and locality. Brentwood limestone: near Fayetteville, Arkansas (Stations 134 and 135). Morrow formation: near Wagoner, Oklahoma (Station 294).

TRILOBITA

PROETIDÆ

Genus GRIFFITHIDES Portlock

Griffithides morrowensis n. sp.

Plate XVI, figures 13-14a.

Description. Cephalon semi-elliptical in shape, about two-thirds as long as wide, measuring the length from the anterior extremity to the posterior edge of the neck ring, moderately tumid; the genal angles prolonged into spines of unknown length; cephalic shield with a striated border passing entirely around its periphery and terminating in the genal spines at either posterior angle; the border wide and sharply deflected to a nearly vertical position posteriorly, gradually becoming less oblique and more narrow anteriorly until in front of the glabella it approaches a horizontal position and is about two-thirds as wide as its posterior width, modified posteriorly by a broad, shallow, rounded depression, occupying more than half

the entire width of the border and parallel to the outer margin of the cephalic shield which becomes obsolete anteriorly and disappears near the point where the facial suture crosses the border; the striations of the peripheral margin are about ten in number with about five on either side of this depression in which the surface of the cephalon is smooth, the outer three or four completely encircling the arc of the shield while the others die out anteriorly at varying distances from the front of the glabella. The outline of the facial sutures very sinuous, the sutures appearing anteriorly at the margin of the shield at some distance from its middle and diverging slightly in a broad curve posteriorly until opposite the mid-length of the glabella, where their direction is changed and they rapidly converge, meeting the glabella just in front of the eyes and making a strong arch around the palpebral lobes. Glabella much wider toward the front than posteriorly, the fixed cheeks crescentic in outline and merging with the border of the cephalic shield in front of the glabella, the palpebral lobes small and occupying slightly less of the cranidium than do the fixed cheeks; the posterior part of the glabella subdivided into three lobes by two obliquely curving furrows which separate the moderately crescentic lateral lobes from the middle larger one which is continuous anteriorly with the remainder of the glabella; there seem to be no transverse furrows in front of the neck furrow. Eye large, elliptical, many-faceted, strongly oblique, and convex transversely as well as longitudinally, forming an obtuse angle with the somewhat oblique free cheek; a small rounded ridge passes around the outer margin of the eye.

Thorax unknown.

Pygidium semi-elliptical in outline, three-fourths as long as wide, broadly rounded posteriorly, with a broad, smooth, oblique, and gently concave border which narrows very slightly anteriorly; the axis strongly elevated and sharply defined from the lateral lobes; semi-elliptical in section; the lateral lobes moderately inflated, the convexity increasing regularly from the grooves which separate them from the axis toward the smooth peripheral border. Segmentation of pygidium strong, produced by deep, sharp grooves which completely cross the axis but die out on the lateral lobes at the margin of the smooth border;

the inner margin of the border defined posteriorly by a faint, rounded depression which becomes obsolete anteriorly opposite the third or fourth segment from the front of the pygidium; about twelve axial rings and about nine lateral ones are present.

The surface of the carapace is marked by fine granules which are more prominent on the posterior portion of the glabella and on the palpebral lobes than elsewhere; no linear arrangement of the granules is apparent on either pygidium or cephalon.

The dimensions of the type, a nearly complete cephalic shield, are: width, 10.1 mm.; length from anterior margin to posterior edge of neck ring, about 6.7 mm.; length of glabella, 4.2 mm. An associated pygidium which is selected as the allotype has the following dimensions: width, 8.4 mm.; length, 6.3 mm.; width of axis, 2.6 mm.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Stations 136, 137, and 149). Brentwood limestone: vicinity of Fayetteville, Arkansas (Stations 135, 138, 148, and 153); Sawney Hollow, Oklahoma (Station 210). Kessler limestone: East Mountain, Fayetteville, Arkansas (Station 209). Morrow formation: near Choteau (Stations 298, 302, and 306), Hulbert (Station 299), and Ft. Gibson (Station 303), Oklahoma.

Griffithides? sp.

Plate XVI, figure 15.

Associated with the type specimen of the last described species was found a fragment of a free cheek of another trilobite whose specific and generic relations are uncertain. The free cheek, itself, is nearly flat and horizontal, but is bordered by an oblique, striated margin of considerable width, which is strongly elevated above the cheek and separated from it by an angular ridge of increasing height as traced anteriorly. The striated border is gently convex and becomes more nearly vertical toward the front.

Horizon and locality. Brentwood limestone: Sawney Hollow, Oklahoma (Station 210).

PISCES

COCHLIODONTIDÆ

Genus DELTODUS Agassiz

Deltodus? sp.

A number of fragments of fish teeth and scales have been observed in the Morrow formations but only two specimens sufficiently complete to give any clue to the type of fishes that lived in the Morrow seas have been recovered. One of these is provisionally placed in the genus *Deltodus* as it is a much worn fragment too incomplete for accurate determination. It seems to correspond more closely to the forms referred to that genus than to any others.

Horizon and locality. Morrow formation: near Ft. Gibson, Oklahoma (Station 303).

PETALODONTIDÆ

Genus PETALODUS Owen

Petalodus sp.

A nearly complete tooth is referable to the genus *Petalodus*. It has the same general characteristics as *P. destructor*, but is considerably smaller than the teeth ordinarily placed in that species.

Horizon and locality. Hale formation: East Mountain, Fayetteville, Arkansas (Station 136).

REGISTER OF LOCALITIES.

134. Fayetteville quadrangle: Brentwood limestone lentil. One and a half miles northeast of Fayetteville, Ark.
    Outcrop near road. Center, sec. 10, T. 16 N., R. 30 W.
135. Fayetteville quadrangle: Brentwood limestone lentil. Three and a half miles northeast of Fayetteville, Ark.
    Abandoned quarry. S. ½, sec. 2, T. 16 N., R. 30 W.
136. Fayetteville quadrangle: limestone lense in Hale formation. Western slope of East Mountain, Fayetteville, Ark.
    Outcrop near Klyce Spring. NW. ¼, sec. 15, T. 16 N., R. 30 W.
137. Fayetteville quadrangle: limestone lense in Hale formation. Southwestern slope of East Mountain, Fayetteville, Ark.
    Outcrop near Confederate cemetery. SW. ¼, sec. 15, T. 16 N., R. 30 W.

138. Fayetteville quadrangle: Brentwood limestone lentil. Eastern slope of East Mountain, Fayetteville, Ark. SW. ¼, sec. 11, T. 16 N., R. 30 W.

139. Fayetteville quadrangle: limestone lense in Hale formation. Ravine on southern slope of East Mountain, Fayetteville, Ark. SE. ¼, sec. 15, T. 16 N., R. 30 W.

140. Fayetteville quadrangle: Brentwood limestone lentil. Same locality as 139.

144. Winslow quadrangle: Kessler limestone lentil. Large talus blocks on slope, three-quarters of a mile northwest of Brentwood, Ark. NE. ¼, sec. 25, T. 14' N., R. 30 W.

145. Winslow quadrangle: Brentwood limestone lentil. Railroad cut, "Acorn Cut," two miles northwest of Brentwood, Ark. S. ½, sec. 23, T. 14 N., R. 30 W.

147. Fayetteville quadrangle: Brentwood limestone lentil. West bluff of Kessler Mountain. Near center of sec. 36, T. 16 N., R. 31 W.

148. Fayetteville quadrangle: Brentwood limestone lentil. Abandoned quarry near negro school, Maple Street, Fayetteville, Ark. NW. ¼, sec. 15, T. 16 N., R. 30 W.

149. Fayetteville quadrangle: limestone lense near top of Hale formation. Southern slope of East Mountain, Fayetteville, Ark.
A. H. Purdue.

150. Fayetteville quadrangle: Brentwood limestone lentil.
Same locality as last, horizon 15 feet higher.
A. H. Purdue.

152. Fayetteville quadrangle: Brentwood limestone lentil. NE. ¼, sec. 20, T. 17 N., R. 29 E.
R. D. Messler.

153. Fayetteville quadrangle: Brentwood limestone lentil. East slope of Baxter Mountain; above 160 feet of Hale sandstones and shales. SE. ¼, sec. 27, T. 16 N., R. 30 W.
A. H. Purdue.

154. Winslow quadrangle: Brentwood limestone lentil. Slopes of mountain east of West Fork, Ark.
A. H. Purdue.

209. Fayetteville quadrangle: Kessler limestone lentil. West slope of East Mountain, Fayetteville, Ark.
Outcrop near city water reservoir.

210. Winslow quadrangle: Brentwood limestone lentil. Sawney Hollow, head of Indian Creek, in Oklahoma, three and a half miles south of Evansville, Ark.

293. Tahlequah quadrangle: lower portion of Morrow formation. 1 mile south of Tahlequah, Oklahoma.
L. C. Snider.

294. Muskogee quadrangle: Morrow formation. About 8 miles east and 2 miles north of Wagoner, Oklahoma; sec. 1, T. 17 N., R. 19 E.
L. C. Snider.

295. Pryor quadrangle: limestone in Morrow formation. 7 miles south of Choteau, Oklahoma. SW. ¼, sec. 30, T. 19 N., R. 19 E.
L. C. Snider.

296. Muskogee quadrangle: lower portion of Morrow formation. Keough quarry, 2 miles northeast of Ft. Gibson, Oklahoma.
Stuart Weller and L. C. Snider.

297. Pryor quadrangle: limestone in Morrow formation. 10 miles east-southeast of Choteau, Oklahoma. W. ½, sec. 4, T. 19 N., R. 20 E.
L. C. Snider.

298. Pryor quadrangle: Morrow formation. Along road 1½ miles south of Choteau, Oklahoma.
L. C. Snider.

299. Muskogee quadrangle: Morrow formation. 1 mile east of Hulbert, Oklahoma. NE. ¼, sec. 25, T. 16 N., R. 20 E.
L. C. Snider.

301. Muskogee quadrangle: Morrow formation; shaly member above heavy limestone. 1½ miles north of Fort Gibson, Oklahoma. Sec. 35, T. 16 N., R. 19 E.
Stuart Weller and L. C. Snider.

302. Pryor quadrangle: Morrow formation; limestone 40 or 50 feet in thickness. Along road near branch of Brush Creek, 2½ miles south and 1 mile east of Choteau, Oklahoma. S. ½, sec. 6, T. 19 N., R. 19 E.
L. C. Snider and J. B. Newby.

303. Muskogee quadrangle: Morrow formation. Hill-side along branch south of Bayou Manard; 4½ miles southeast of Fort Gibson, Oklahoma. Sec. 21, T. 15 N., R. 20 E.
D. W. Ohern and L. C. Snider.

304. Muskogee quadrangle: limestone in upper portion of Morrow formation. Hill east of railroad, 3 miles northwest of Gore, Oklahoma (Campbell on topographic sheet).
L. C. Snider.

305. Muskogee quadrangle: upper portion of Morrow formation. Near Illinois River, 4 miles north and 1 mile east of Gore, Oklahoma (Campbell on topographic sheet). NE. ¼, sec. 20, T. 13 N., R. 21 E.
L. C. Snider.

306. Pryor quadrangle: Morrow formation. About 6 miles south-southeast of Choteau, Oklahoma. S. ½, sec. 17, T. 19 N., R. 19 E.
L. C. Snider.

307. Pryor quadrangle: limestone in Morrow formation. North side of Flat Rock Creek, about 6 miles south of station 306. Along line between secs. 17 & 18, T. 18 N., R. 19 E.
L. C. Snider.

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PLATE I.

Figs. 1-2. ZAPHRENTIS GIBSONI White ....p. 89

1, 1a. Two views of a nearly complete specimen showing the primary and alar septa. 2. Transverse section of another individual in the immature region, x2. Morrow formation, Station 296.

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16. A corrallum of medium size. Brentwood limestone, Station 145.

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17. A small corallum, displaying the wrinkled epitheca which covers the basal portion. 17a. Longitudinal section of the same, showing the thick walls and thin tabulae which characterize the species. Morrow formation, Station 301.

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18. One of the cotypes. Morrow formation, Station 301.

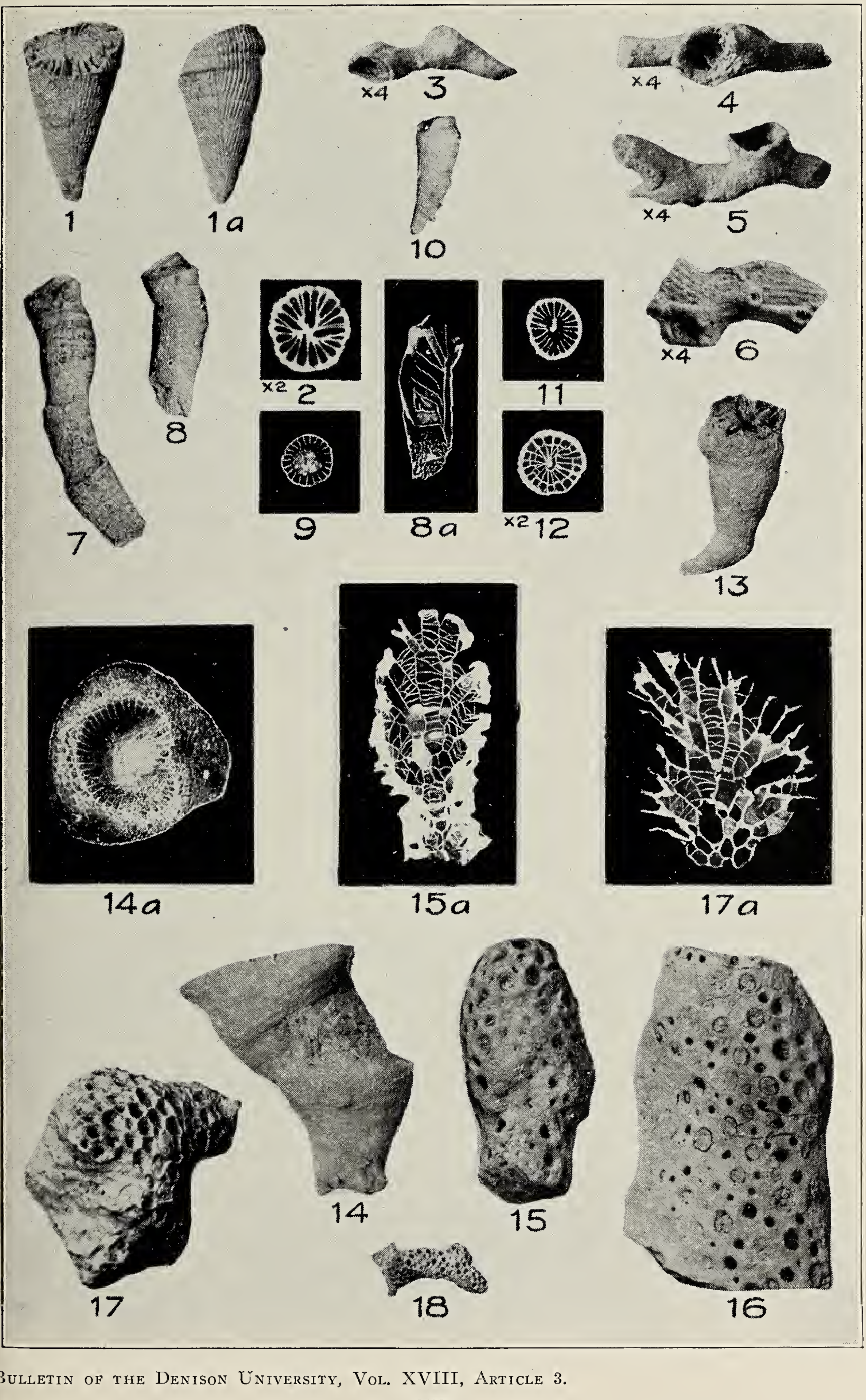
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PLATE II.

Fig. 1. MICHELINIA EUGENEAE White..p. 95

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Figs. 2, 2a. MICHELINIA EXILIMURA n. sp. ....p. 96

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4, 4a. Two views of a primibrachial plate of an unknown crinoid, possibly a *Delocrinus*. Morrow formation, Station 301.

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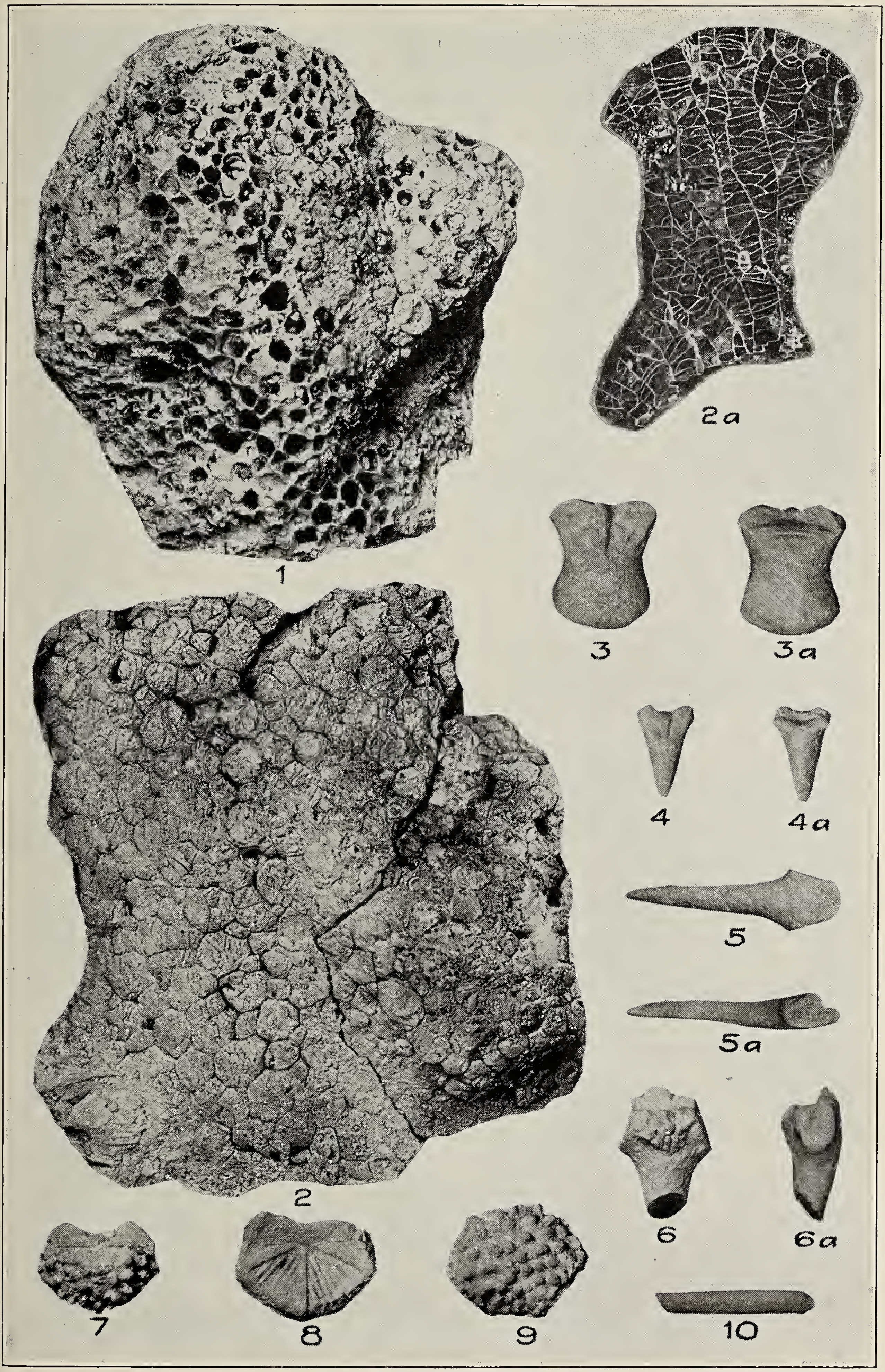
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Figs. 1-1b. DELOCRINUS sp. ....p. 108
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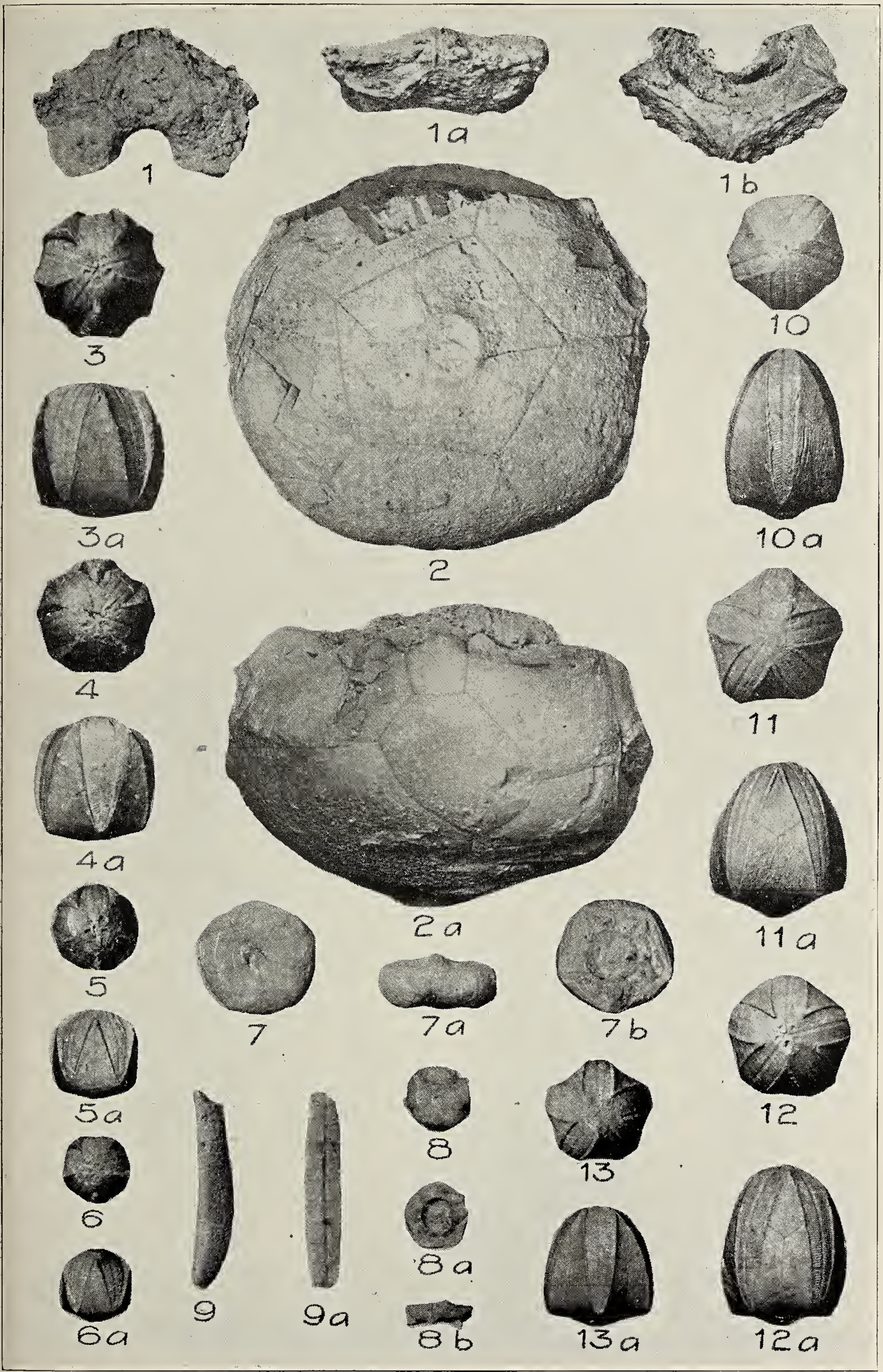
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PLATE IV.

Figs. 1, 2. FISTULIPORA sp. ....p. 110

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Figs. 3-5. STENOPORA TUBERCULATA Prout.......................................p. 111

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Figs. 7, 8. ANISOTRYPA sp. ....p. 112

7. Tangential section, x4. 8. A zoarium, x4. Brentwood limestone, Station 134.

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9. Obverse face of a zoarium, x4. Morrow formation, Station 296.
10. The zoarium selected as the holotype, reverse face. 10a. A portion of the same enlarged four diameters. Hale formation, Station 136.

Figs. 11, 11a. FENESTELLA MORROWENSIS n. sp. ....p. 115

11. The type specimen, obverse face. 11a. A portion of the same, x4. Morrow formation, Station 301.

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12. The type shaft. 12a. Longitudinal section of the same. Brentwood limestone, Station 153.

Figs. 13-14. POLYPORA PURDUEI n. sp. ....p. 118

13. The type zoarium, obverse face. 13a. A portion of the same, x4. Hale formation, Station 136.
14. Reverse face of another zoarium. Brentwood limestone, Station 150.

Figs. 15, 15a. POLYPORA WASHINGTONENSIS n. sp. ....p. 119

15. A portion of the type zoarium, reverse face. 15a. Another portion of the same, ground and polished to give a tangential section near the obverse face, showing zooecial arrangement, x4. Brentwood limestone, Station 150.

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17. Reverse face of another zoarium, showing the deep funnel-shaped fenestrules which characterize the species. Morrow formation, Station 299.

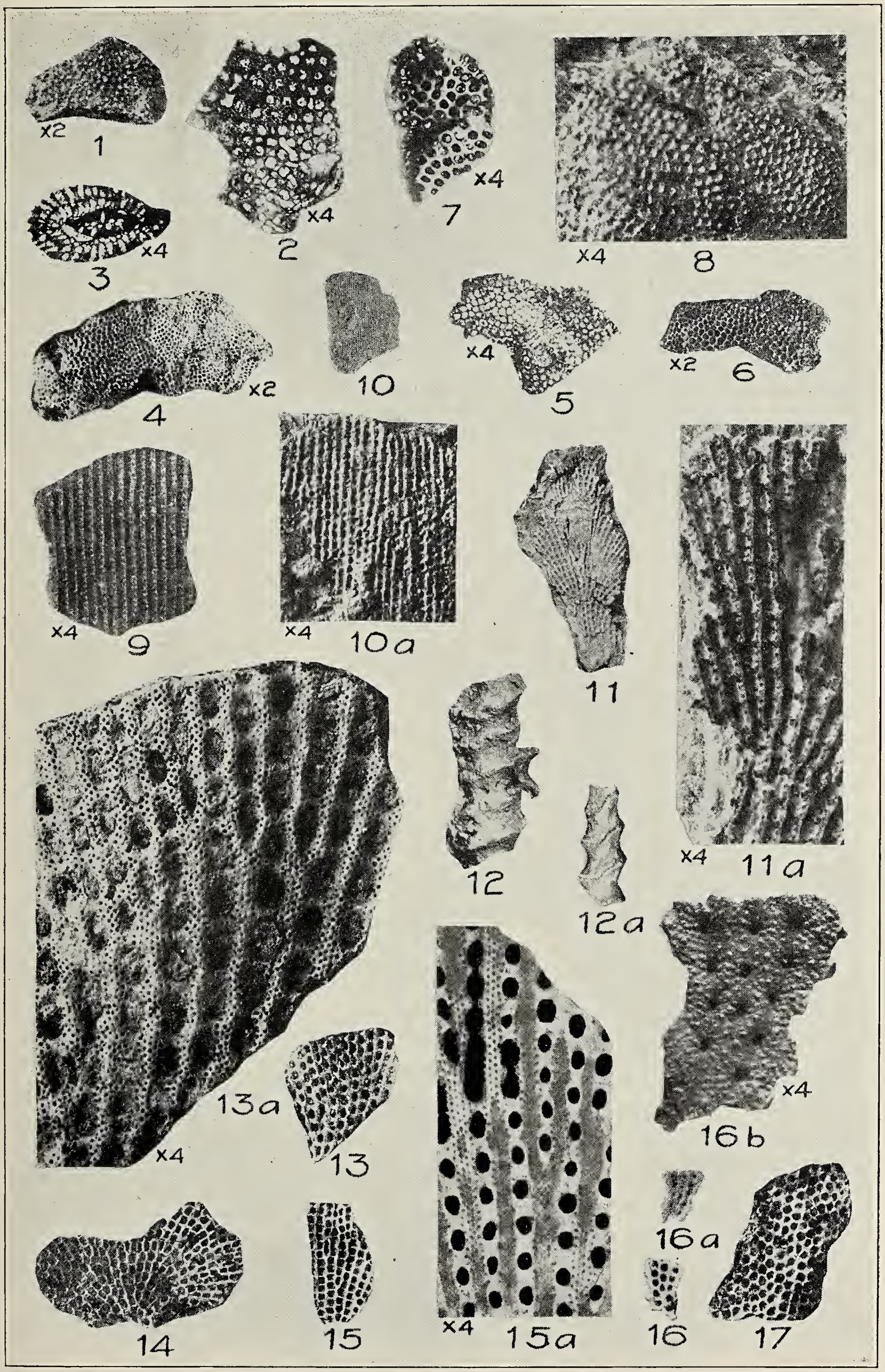
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PLATE V.

Figs. 1, 1a. POLYPORA MAGNA n. sp. ....p. 122

1. The type zoarium, reverse face exposed. 1a. A portion of the same, ground and polished to give a tangential section near the obverse face, showing zooecial arrangement, x4. Brentwood limestone, Station 145.

Figs. 2-3. POLYPORA TRISERIATA n. sp. ....p. 116

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3. Another zoarium, reverse face exposed. Brentwood limestone, Station 150.

Figs. 4, 4a. POLYPORA REVERSISPINA n. sp. ....p. 124

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Figs. 5, 5a. PHYLLOPORA PERFORATA n. sp. ....p. 126

5. The holotype, a zoarium with the obverse face exposed. 5a. A portion of the same, x4. Hale formation, Station 136.

Figs. 6, 6a. POLYPORA KESSLERENSIS n. sp. ....p. 123

6. The type zoarium, obverse face exposed. 6a. The same, x4. Kessler limestone, Station 209.

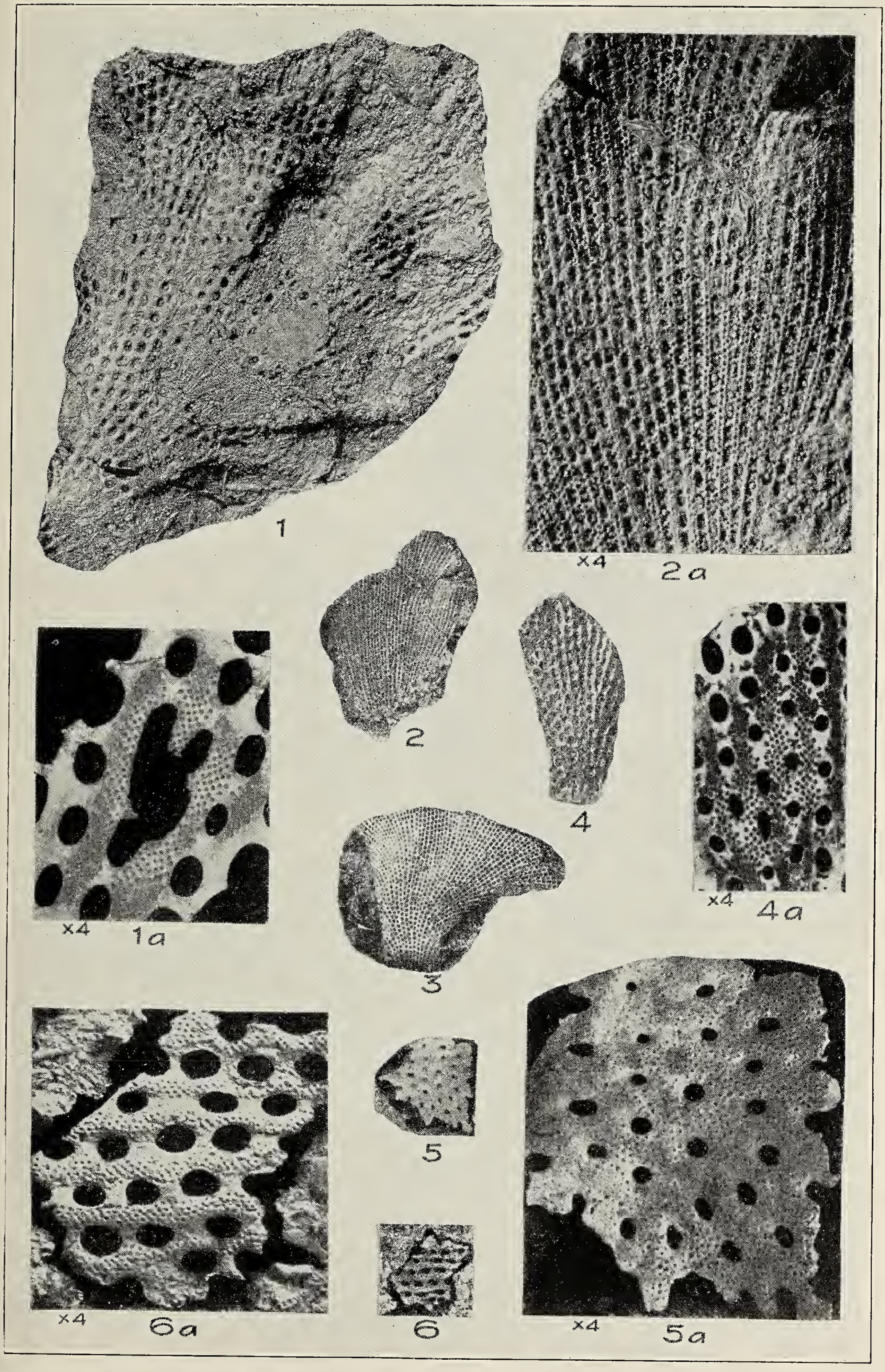
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PLATE VI.

Figs. 1, 1a. SEPTOPORA CREBRIPORA n. sp. ....p. 128

1. The type zoarium, reverse face, abraded in several places so that the arrangement of the zooecia is displayed. 1a. A portion of the same, x4. Hale formation, Station 136.

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Figs. 3, 3a. POLYPORA HALENSIS n. sp. ....p. 121

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Figs. 4, 4a. POLYPORA ANASTOMOSA n. sp. ....p. 125

4. The type zoarium, reverse face exposed. 4a. A portion of the same, ground and polished to give a tangential section near the obverse face, showing the zooecial arrangement, x4. Hale formation, Station 136.

Figs. 5, 5a. PHYLLOPORA CRIBROSA n. sp. ....p. 127

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Figs. 8, 9. RHOMBOPORA LEPIDODENDROIDES Meek ....p. 132

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Fig. 11. RHOMBOPORA TABULATA Ulrich..............................p. 133

11. A typical zoarium, x4. Morrow formation, Station 301.

Fig. 12. SEPTOPORA IMPLEXA n. sp. ....p. 129

12. The type zoarium; the abraded reverse face exposed. Brentwood limestone, Station 134.

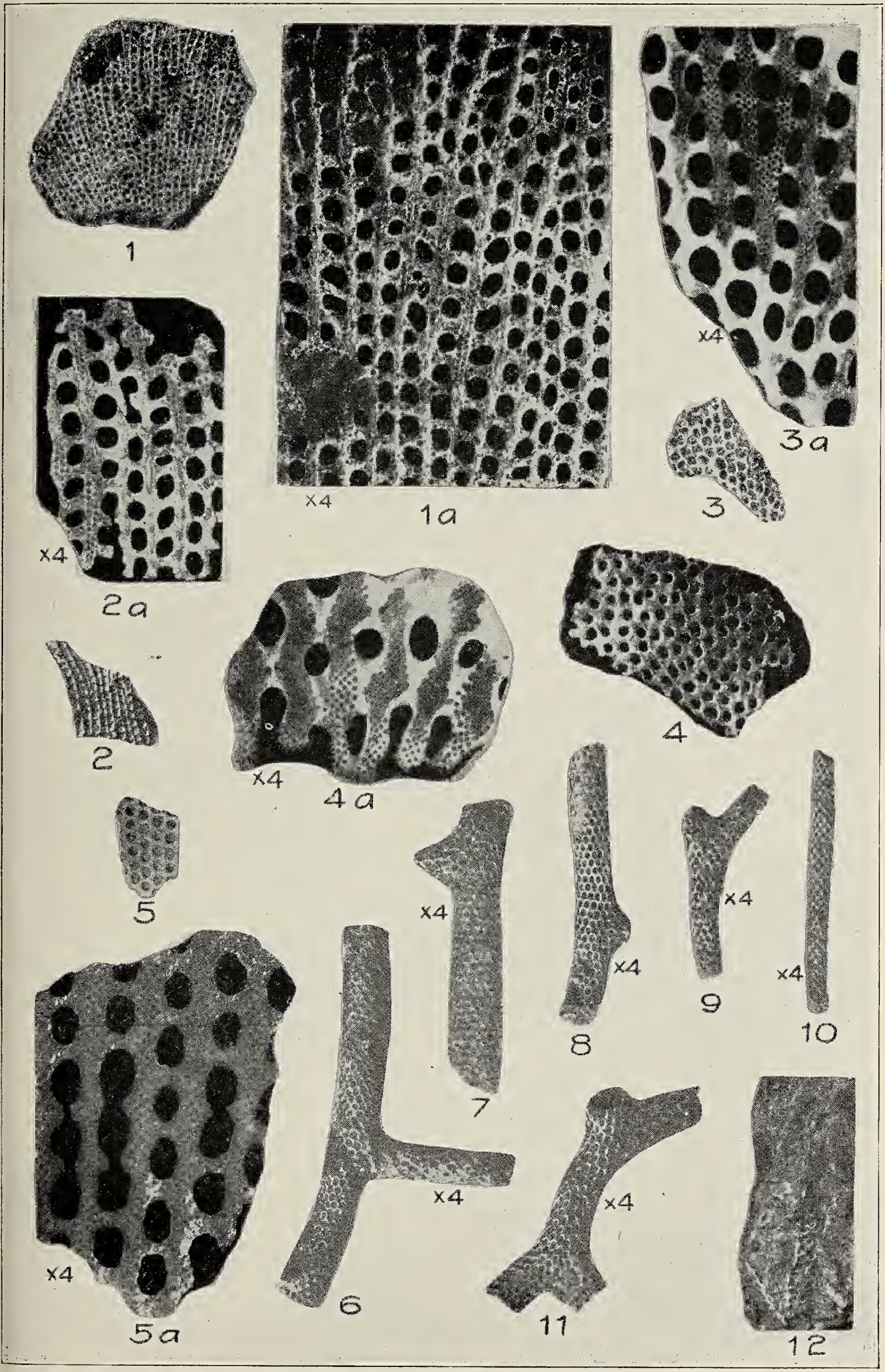
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PLATE VII.

Figs. 1, 1a. CYSTODICTYA BRENTWOODENSIS n. sp. ....p. 135
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Figs. 2, 2a. GLYPTOPORA CRASSISTOMA n. sp.... ....p. 140
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Fig. 3. COSCINIUM FAYETTEVILLENSIS n. sp. ....p. 138
3. The holotype, an individual showing the basal attachment scar. Brentwood limestone, Station 135.

Fig. 4. COSCINIUM GRACILENS n. sp. ....p. 139
4. The holotype. Brentwood limestone, Station 134.

Figs. 5-6a. CYSTODICTYA MORROWENSIS n. sp. ....p. 138
5, 6. Two of the cotypes. 5a, 6a. The same, x4. Morrow formation, Station 301.

Figs. 7, 7a. PRISMOPORA CONCAVA n. sp. ....p. 140
7. The specimen selected as the holotype. 7a. A portion of the same, x4. Kessler limestone, Station 209.

Figs. 8-9a. CYSTODICTYA FLEXUOSA n. sp. ....p. 137
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Figs. 11, 11a. CYSTODICTYA SINUOMARGINATA n. sp. ....p. 136
11. The holotye. 11a. The same, x4. Brentwood limestone, Station 135.

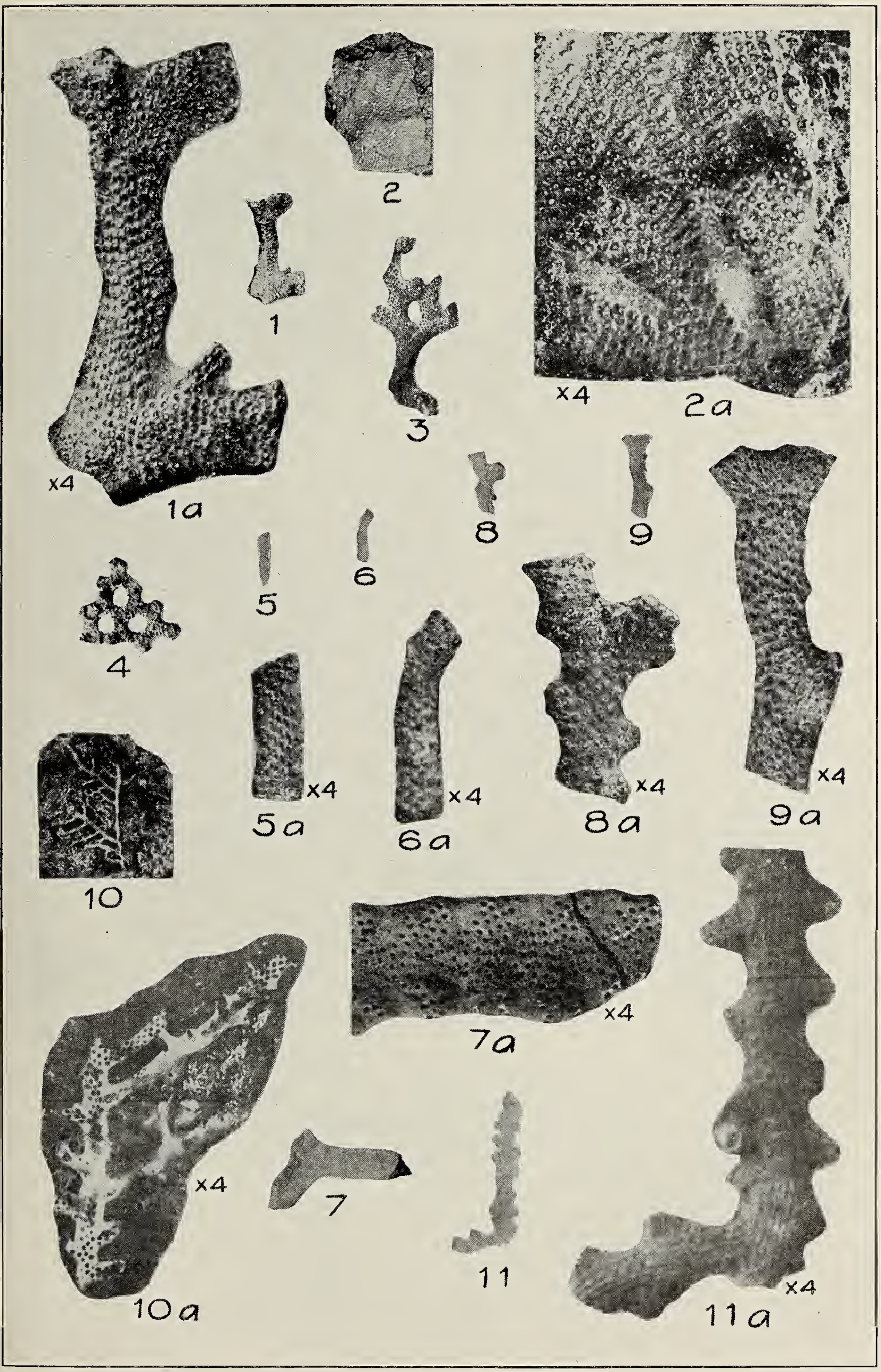
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PLATE VIII.

Fig. 1. ORBICULOIDEA MISSOURIENSIS (Shumard)?..................p. 142

1. An incomplete brachial valve, x2. Brentwood limestone, Station 210.

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Fig. 4. CHONETES ARKANSANUS n. sp. ....p. 149

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Figs. 6-8. SCHIZOPHORIA RESUPINOIDES Cox..................................p. 145

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8. Exterior of a brachial valve above the average size. Morrow formation, Station 304.

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Figs. 13, 14. CHONETES LAEVIS Keyes. ....p. 151

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Figs. 15-15b. PUSTULA BULLATA n. sp. ....p. 174

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Figs. 16-16b. PRODUCTUS sp. ....p. 165

16, 16a, 16b. Lateral, anterior, and cardinal views of the pedicle valve. Kessler limestone, Station 209.

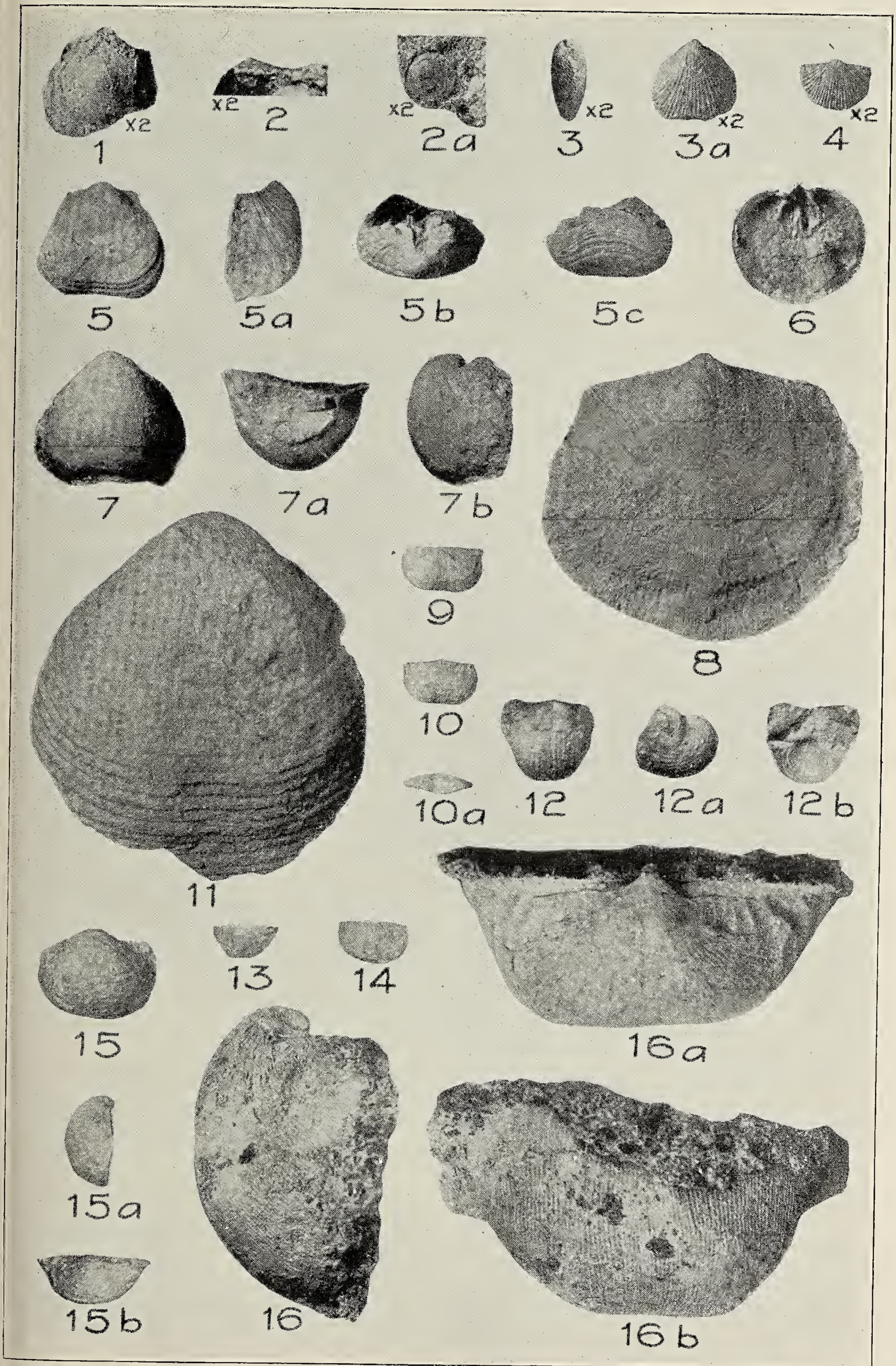
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PLATE IX.

Figs. 1-1c. PUSTULA SUBLINEATA n. sp. ....p. 168

1, 1a, 1b, 1c. Pedicle, cardinal, lateral, and brachial views of the holotype. Brentwood limestone, Station 152.

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3, 3a. Pedicle and cardinal views of a typical pedicle valve. Brentwood limestone, Station 153.

Figs. 4-5b. PRODUCTUS GALLATINENSIS Girty. ....p. 163

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Figs. 6, 7. PUSTULA NEBRASKENSIS (Owen). ....p. 169

6. An incomplete pedicle valve of the average size. Kessler limestone, Station 144.

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Fig. 8. ORTHOTETES ? sp. ....p. 147

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Figs. 9, 9a. PUSTULA PERTENUIS (Meek). ....p. 165

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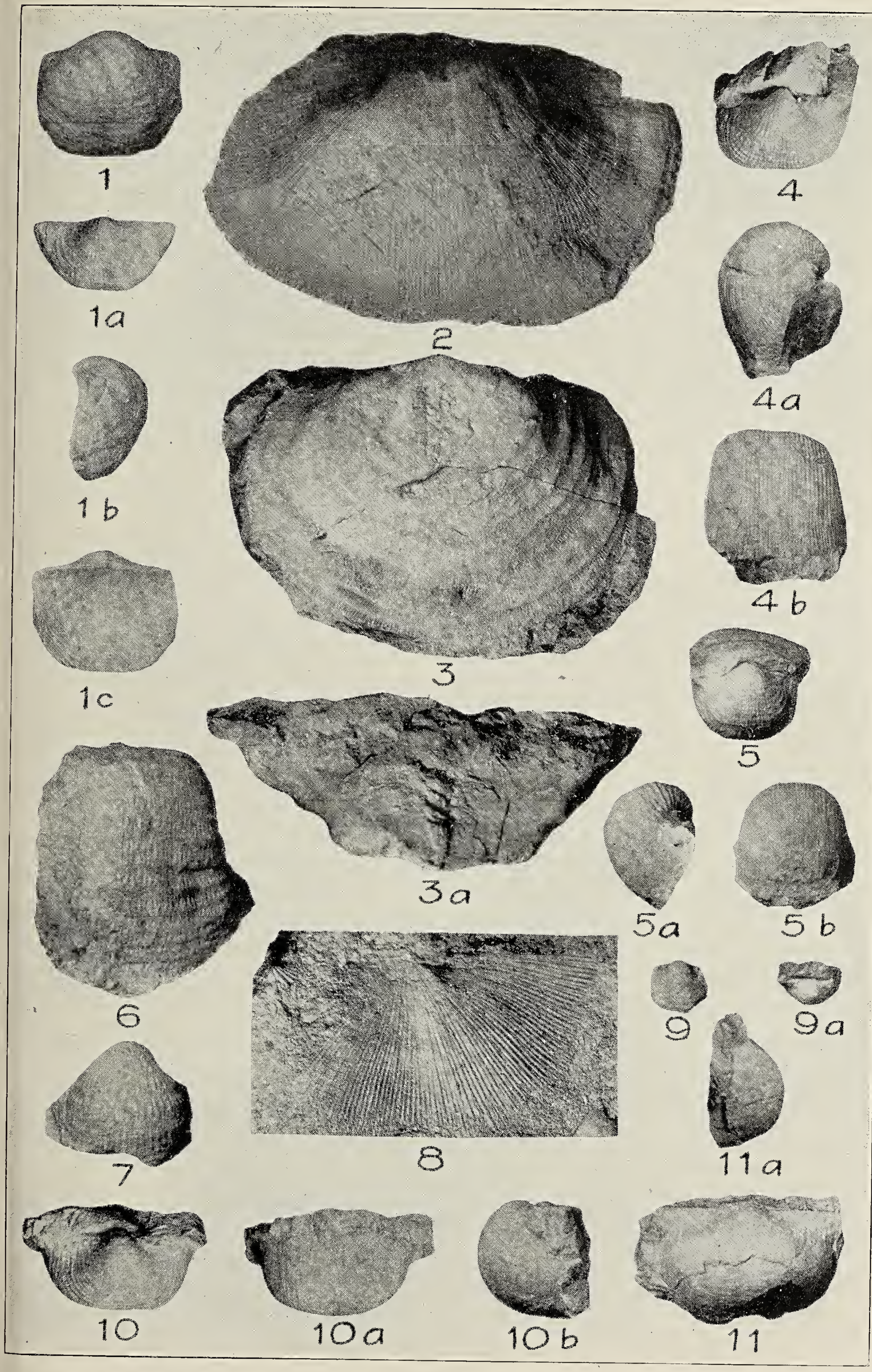
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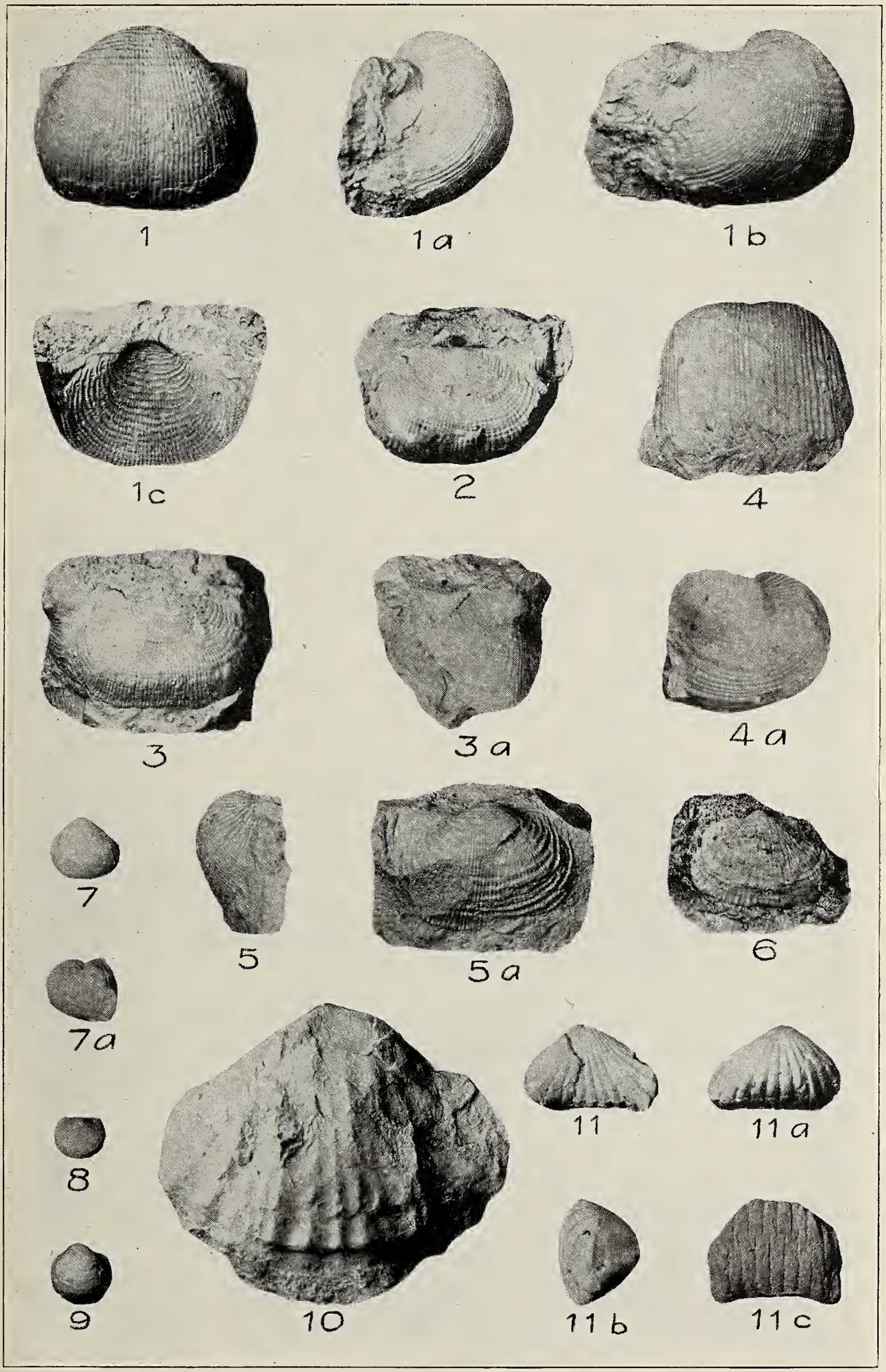
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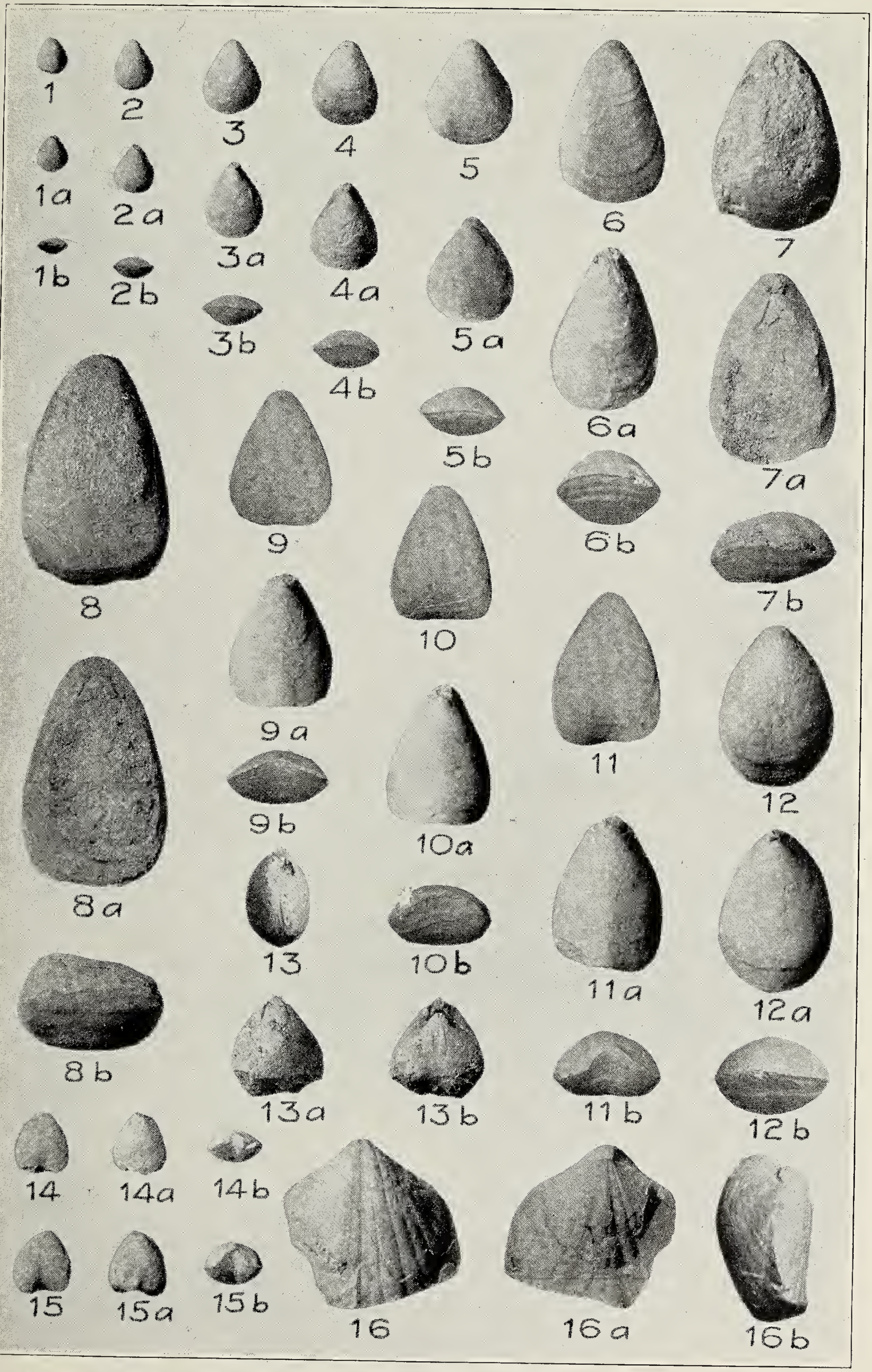
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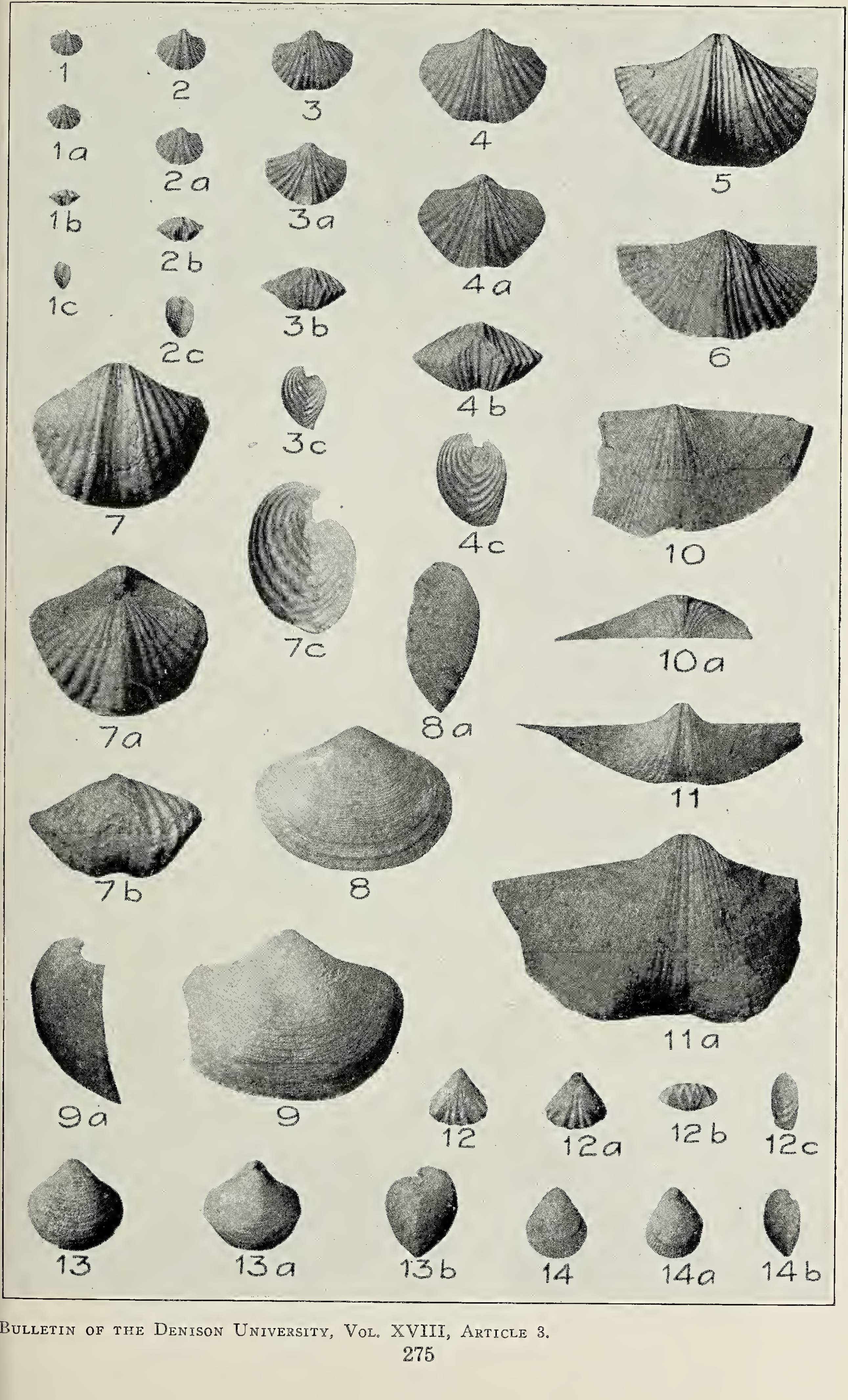
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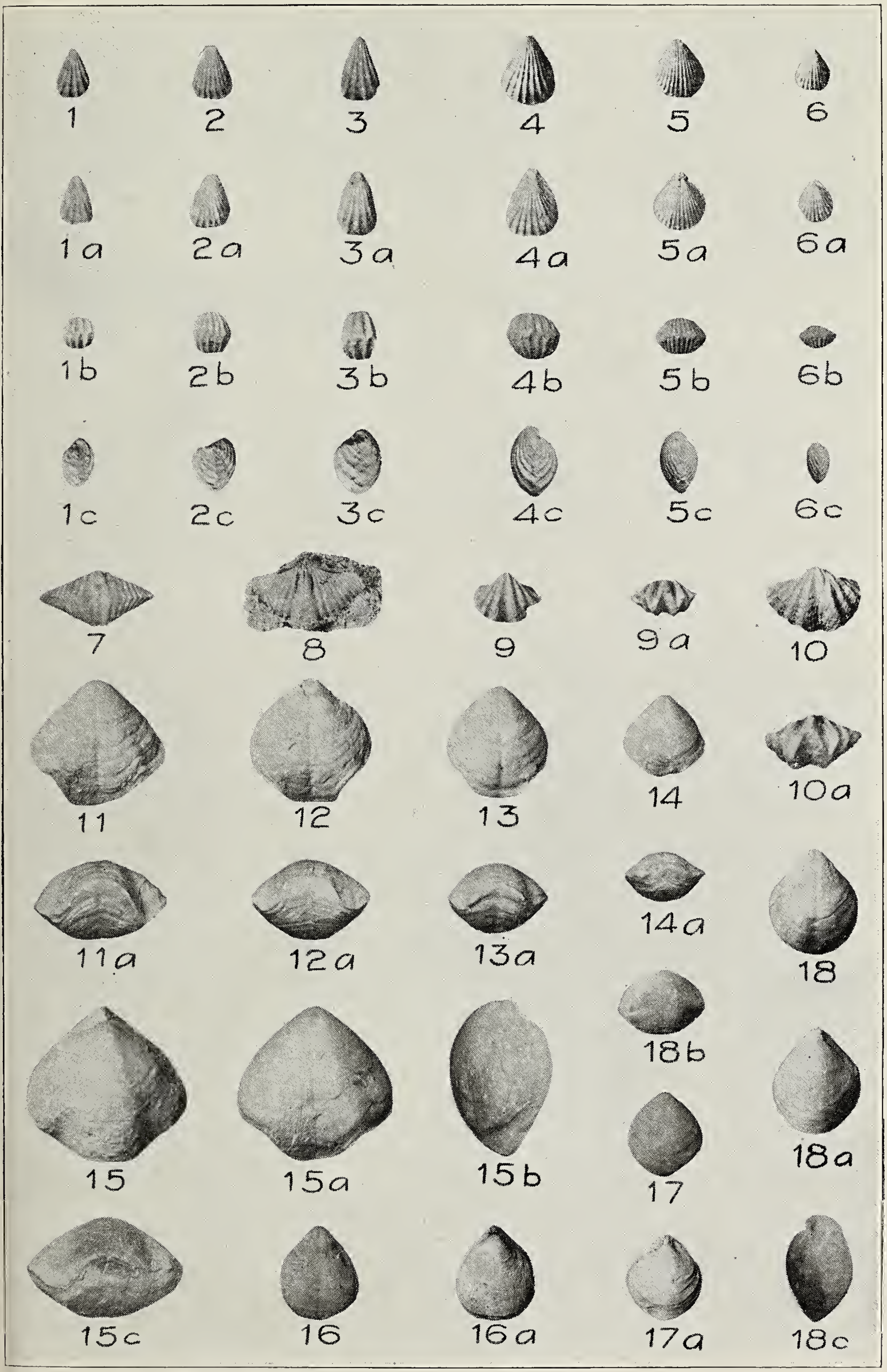
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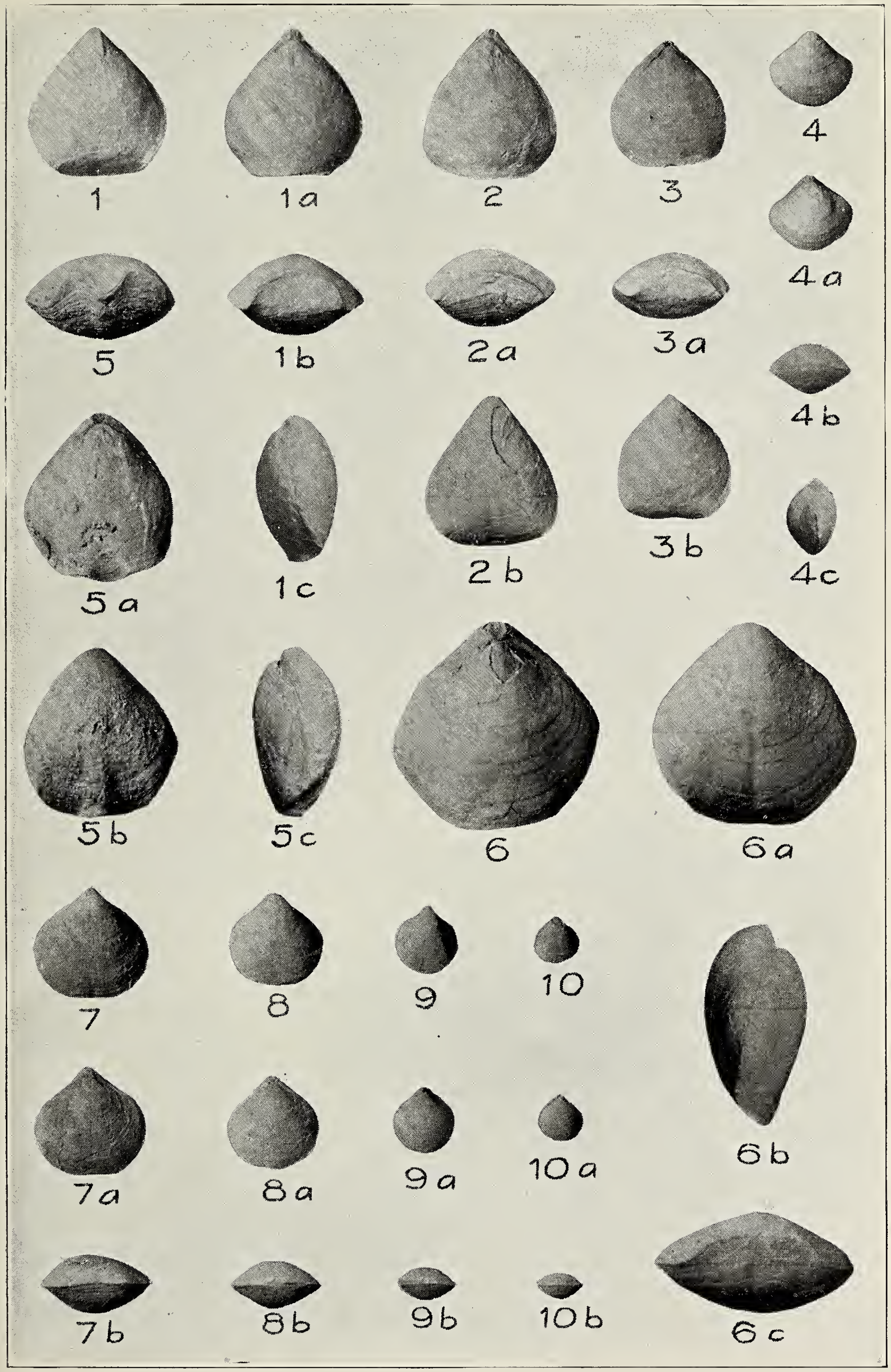
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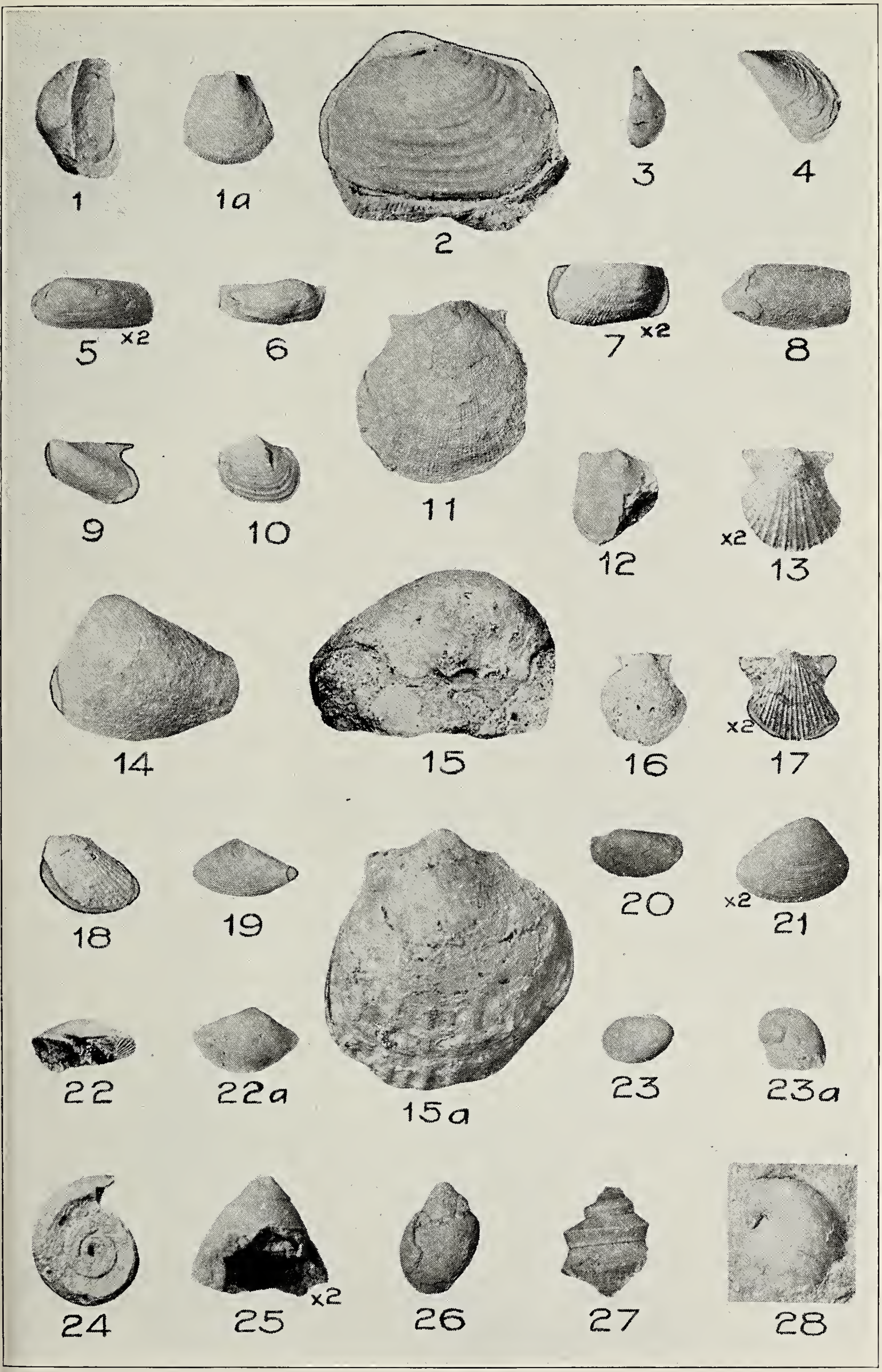
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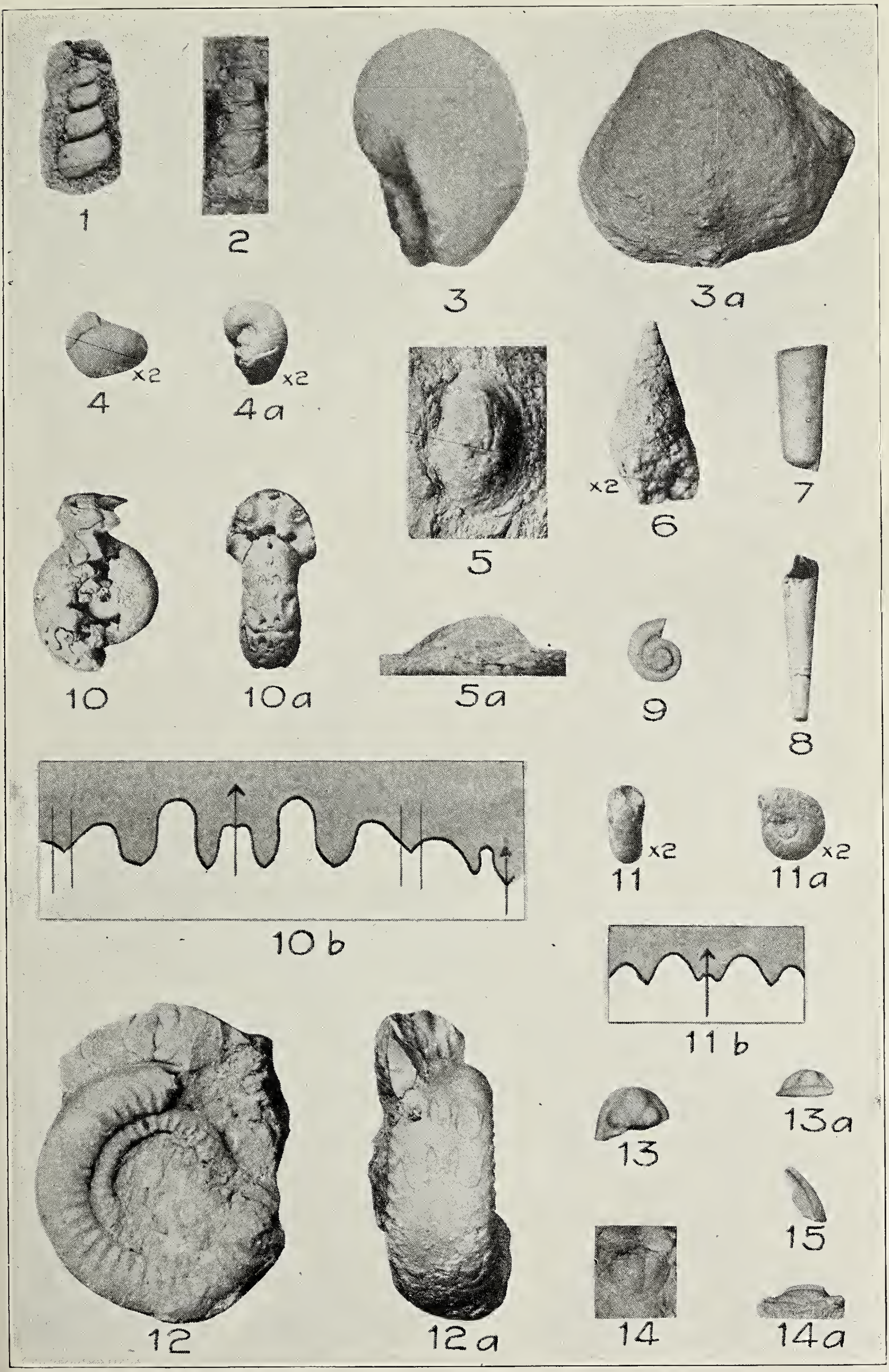
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DENISON UNIVERSITY BULLETINS NEW SERIES NO. 62

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NOTES ON CINCINNATIAN FOSSIL TYPES

AUG. F. FOERSTE

The more exact study of the stratigraphy of the Cincinnatian formations requires a closer discrimination of fossil species and varieties than was thought necessary formerly, when the entire series of Cincinnatian strata was regarded as fairly homogeneous, not only lithologically but also in fossil content. However, a closer discrimination of fossil species and varieties requires a more definite knowledge of the limits to be assigned to the forms already described, and for this purpose an accurate knowledge of the characteristics of the described and figured types is desirable. It was in order to secure this knowledge that the series of studies of Cincinnatian fossils published in this Bulletin, and of which the present is another contribution, was undertaken. It is not intended in these studies to revive the names of all the so-called species here discussed. Many of these names have been discarded happily long ago. It is regarded desirable, however, to place on record exactly what all of the so-called species are, giving, wherever possible, illustrations of the figured types, produced by photographic methods. In some cases the study of the type material has not resulted in definite conclusions, but it is hoped that, even in their present imperfect condition, these notes may be found serviceable.

On the following pages, in order to facilitate reference to these types, the original specific term applied to the type is retained as a heading even in those cases in which there is every reason to believe that this term is merely a synonym of some earlier described species. The generic reference however is altered whenever necessary in order to conform with present usage. This should lead to no confusion, since all available information, suggesting synonomy, is embodied in the accompanying text.

1. Pasceolus claudei Miller
2. Pasceolus tumidus James
3. Dystactospongia madisonensis Foerste
4. Dystactospongia (?) cavernosa n. sp.
5. Leptopoterion faberi Miller
6. Protaraea vetusta Hall

7. Calapoecia cribriformis Nicholson
8. Tetradium ontario Hall
9. Dermatostroma papillatum James
10. Dermatostroma scabrum James
11. Dermatostroma glyptum Foerste
12. Stromatocerium granulosum James
13. Stromatocerium montiferum Ulrich
14. Stromatocerium indianense James
15. Stromatocerium huronense australe Parks
16. Lingula covingtonensis Hall and Whitfield
17. Lingula vanhornei Miller
18. Lingula brookvillensis n. sp.
19. Trematis crassipuncta Ulrich
20. Trematis fragilis Ulrich

Craniae of the Richmond group

21. Crania scabiosa Hall
22. Crania multipunctata Miller
23. Crania costata James
24. Crania asperula James.
25. Crania alternata James

Craniae from the Economy member of the Richmond group

26. Crania dyeri Miller
27. Crania percarinata Ulrich
28. Crania parallela Ulrich
29. Crania socialis Ulrich
30. Crania albersi Miller and Faber

31. Whitella cuneiformis Miller
32. Whitella richmondensis Miller
33. Cyrtodonta cuneata Miller
34. Anomalodonta alata Meek
35. Anomalodonta costata Meek
36. Byssonychia robusta Miller
37. Cymatonota cylindrica Miller and Faber
38. Modiolopsis versaillesensis Miller
39. Modiolopsis brevantica n. sp.
40. Pholadomorpha pholadiformis Hall
41. Pholadomorpha divaricata Hall and Whitfield.
42. Pholadomorpha capax Miller
43. Pholadomorpha corrugata Miller and Faber
44. Pholadomorpha sulcata Miller and Faber
45. Rhytimya cymbula Miller and Faber
46. Vallatotheca manitoulini Foerste
47. Endoceras arcuatum James, J. F.
48. Caliculospongia pauper, gen. et sp. nov.
49. Carneyella and Isorophus, gen. nov.

1. Pasceolus claudei, Miller

Plate III, Figure 2

1874. Pasceolus claudei Miller, Cincinnati Quart. Jour. Sci., vol. I, p. 6, Fig. 3

The cotypes at present form No. 8837 in the Faber collection in the Museum at Chicago University. Of these, one resembles in size and form the figure accompanying the original description, and this specimen is here illustrated. The general outline of the surface plates, as determined from the concave depressions left behind on this cast of the interior of the organism, was hexagonal rather than pentagonal. The absence of a depression at the base of the specimen evidently is not a distinctive characteristic since a specimen of *Pasceolus claudei* in the Dyer collection at Harvard University shows such a depression. Specimens with surface plates intermediate in size between those of typical *Pasceolus claudei* and *Pasceolus darwini* occur at the type locality and horizon: 2 miles south of Maysville, Kentucky, along the railway, at the base of the Bellevue member of the Maysville. It is not certain whether *Pasceolus claudei* is to be regarded merely as the young of *Pasceolus darwini*, or as a distinct species. It is assumed that the exterior surface of the surface plates was concave, as in *Pasceolus darwini*.

2. Pasceolus tumidus, James

(Plate III, Fig. 1)

1878. Astylospongia tumidus James, Paleontologist, 1, p. 1

1891. Pasceolus (?) tumidus James. Jour. Cincinnati Soc. Nat. Hist., 14, p. 59, Fig. 3

The cotypes at present form No. 1222 in the James collection in the Museum at Chicago University, and are labelled as coming from an elevation of 350 feet above low water in the Ohio river at Cincinnati. This should place them approximately in the upper part of the Fairmount member of the Maysville.

The surface plates have an hexagonal outline. Three plates occupy a width of 6 millimeters. The exterior surface of the plates is concave, and distinct grooves extend from the angles toward the center, toward which they widen and at which they coalesce. The depressions left by these plates, where they have weathered away, are concave. There is no indication of a short spine extending from the center of the inner surface of these plates toward the interior of the spherical space which these plates surround; nor

is there any evidence of the individual plates being hollow and there scarcely is room for such a hollow space between the exterior and interior surfaces of these plates. The general form of the specimens is subglobose, more or less depressed, with a depression on that side usually regarded as the base. The stellate grooves were first described and figured by Joseph F. James, the son of the original describer, and one of the cotypes preserving these features to a marked degree is here illustrated.

Similar stellate markings have been found on the exterior surface of the plates in specimens of *Pasceolus darwini* Miller, at the base of the Bellevue member of the Maysville, 2 miles south of Maysville, Kentucky, along the railway. In fact, stellate markings occur on a plate preserved on one of the cotypes of this species at present in the Faber collection at Chicago University, and obtained at this locality and horizon. This series of cotypes is numbered 8838, and is assumed to include also the specimens figured in the original description of *Pasceolus darwini.*

In his original description of *Pasceolus darwini* (1874, Cincinnati Quart. Jour. Sci., 1, p. 5, figs. 1, 2), Miller states that fragments and poor specimens occur also on the hills back of Cincinnati, at an elevation of about 400 feet above low water mark. This may correspond to the Bellevue horizon, *Pasceolus tumidus* having been described by James from about 350 feet above low water.

An examination of numerous specimens of *Pasceolus* from the middle of the Maysville in Kentucky and Ohio suggests that *Pasceolus darwini*, *Pasceolus claudei*, and *Pasceolus tumidus* all belong to the same species. They all contain from 15 to 17 plates along a line drawn transversely across the so-called upper surface of the specimen, indicating that from 30 to 35 of these plates should occur along a great circle surrounding the subglobose specimens. From this it is evident that difference in the size of the plates is due to a corresponding difference in the size of the entire specimen, and suggests a difference in the stage of growth of the individuals, rather than a specific difference. In a similar manner, only the larger specimens, from 25 to 30 millimeters in diameter usually present the distinct but rather shallow depressions on that side usually regarded as the base of the specimen, while specimens from 20 to 25 millimeters in diameter usually show only a faint trace of this basal depression, and on still smaller specimens this depression usually is absent.

That the concave curvature and stellate grooving of the exterior surface of the plates is not confined to Maysville forms is indicated by a specimen (1914, Bulletin, Denison Univ., 17, pl. 4, fig. 4), found a short distance beneath the Fulton clay shale, containing the characteristic *Triarthrus becki*, in the upper part of the Point Pleasant beds of Orton, at the quarry located a quarter of a mile west of Point Pleasant, Ohio. In this specimen, the division lines between the plates are indicated by sharply impressed narrow grooves. The plates are hexagonal and concave; and distinctly impressed and relatively broad grooves extend from the angles of the plates toward the center, where they unite. The plates, apparently, must have been thin and practically there is no room for a concavity within the individual plates.

This structure evidently is quite distinct from that of *Pasceolus halli* Billings, the first described and first illustrated species of the genus, ranging from the Gamachian series, younger than the Richmond, into the Silurian strata of Anticosti. In this species, the exterior surface of all of the plates is distinctly convex. The plates probably are hollow, their lower surface is convex, and a short spine extends from the center of the base of each plate toward the center of the specimen. The short spine may be seen distinctly in specimens of *Pasceolus gregarius* Billings, a smaller sized species occurring in the Silurian strata of Anticosti after the disappearance of typical *Pasceolus halli*.

Apparently there are two groups of species included in *Pasceolus*, the group typified by *Pasceolus halli*, with convex plates, and the group typified by *Pasceolus darwini*, with concave plates and stellate grooves. The former usually are strongly calcareous. The latter occur in strongly argillaceous strata. The former occasionally preserve very delicate surface markings. In the latter no surface markings ever have been noticed in addition to the stellate grooves already described. This has raised the question whether it might not be possible that the so-called plates of the *darwini* group of *Pasceolus* in reality represent only the basal parts of the plates, the upper and lateral parts having been removed by weathering. In that case the stellate grooves would be features characterizing that part of the base of the plate which faces the hollow in the interior of the plate; and the grooves would converge toward the point of departure of the spine. I have not been able to either prove or disprove this hypothesis, with the specimens at my command.

Formerly, all the specimens of *Pasceolus* discovered in Cincinnatian strata were identified as *Pasceolus globosus.* This species was originally described by Billings from the Trenton, at Ottawa, Canada. *Pasceolus globosus* presents convex areas in the spaces evidently outlined by the vertical lateral margins of the plates. From this it is assumed that the exterior surfaces of the plates were convex, but I have seen no specimens in which these exterior surfaces actually were preserved. In other specimens, the depressions left by the inner surfaces of the plates are distinctly concave, but no indication of a short spine projecting from the center of the base of the plate toward the interior of the specimen is seen, nor is there any evidence of the presence of stellate grooves. Apparently, *Pasceolus globosus* is more closely related to *Pasceolus halli* than to the *Pasceolus darwini* group of species, and therefore, for the present, the name *Pasceolus globosus* is dropped from the list of Kentucky and Ohio species. Evidently, our present knowledge of the various so-called species of *Pasceolus* is in a very unsatisfactory condition.

3. **Dystactospongia madisonensis,** Foerste

(*Plate III, Fig. 4*)

1909. Dystactospongia madisonensis Foerste, Bull. Sci. Lab. Denison Univ., 14, p. 302, Plate 9, Figs. 1, 5. Also 1910, 16, p. 20

The specimen here figured, from a layer seven feet above the chief *Columnaria alveolata* horizon, near the base of the Saluda member of the Richmond, at Madison, Indiana, presents no evidence of the presence of oscula, or canals. This is true also of the specimen represented by figure 1 on plate 9, accompanying the original description of this species. In the Versailles specimen, represented by figure 5 on the same plate, oscula are readily discernible. Both the forms with and without oscula occur at the same horizon, and at the same localities, often intermingled. They have the same habits of growth, figure 5, on the plate cited above, being a part of a specimen having the same lobate growth as figure 1 on the same plate. The specimen, figure 1, from Madison, Indiana, is regarded as the type of the species, with which the specimen with oscula, figure 5, from Versailles, Indiana, is correlated, at least provisionally.

4. **Dystactospongia ? cavernosa, n. sp.**

(*Plate III, Fig. 3*)

Specimen 90 millimeters in length, 58 millimeters in width, and 36 millimeters in thickness, showing at the surface numerous

irregular cavities, averaging between two and three millimeters in diameter. These cavities are not the openings of tubes or canals and, therefore, do not correspond to oscula. Both laterally and toward the interior they are bounded by an intricate mass of fibrous tissue, separating the cavities from each other. The fibrous tissue between the cavities averages between one-fourth and three-fourths of a millimeter in thickness, although frequently equalling two millimeters at the angles between the cavities. This fibrous tissue is calcareous, and branches and anastomoses in a very irregular manner, so as to enclose smaller interspaces averaging between one-fourth and one-half of a millimeter in diameter, the smallest recognizable interspaces equalling scarcely one-fifth of a millimeter in diameter. Throughout the entire specimen the structure is very irregular. There is no central cavity, and no radiating structure extending from the central axis of the specimen toward the surface.

There are no large radiate oscula at the surface, as in *Dystactospongia insolens* Miller. The fibrous structure resembles that of *Heterospongia*, but there are no "branching and more or less tortuous canals, which begin near the center, where they are nearly vertical, and proceed toward all portions of the surface in a curved direction," as in *Heterospongia subramosa* (Geol. Minnesota, 3, pt. 1, 1895, pl. G, figs. 5, 6.). There is no large gastral cavity, there are no more or less numerous lobes at the surface, nor basal bundles of more or less parallel filaments for attachment, as in *Pattersonia difficilis* Miller. The structure of the specimen here described, therefore, seems to be different from that of any form hitherto described from the vicinity of Cincinnati, and a new generic designation may eventually prove desirable.

The original label has been lost, but the specimen is known to have been obtained at Cincinnati, Ohio, and probably was found in the middle part of the Maysville group.

5. **Leptopoterion faberi,** Miller

(*Plate II, Fig. 2A, 2B*)

1889. Leptopoterion mammiferum Ulrich, Am. Geol., 3, pp. 239
1889. Chirospongia faberi Miller, N. A. Geol. Pal., p. 156, Fig. 99

The type of *Leptopoterion mammiferum* was found in the Corryville division of the Maysville, in the quarries on Roh's hill, at Cincinnati, Ohio, by Prof. Charles Schuchert, and was stated in the original description to be in the Ulrich collection, but it is not listed

among the types in the Ulrich collection in the U. S. National Museum, at Washington.

The type of *Chirospongia faberi* is preserved in the Faber collection at Chicago University; it is numbered 8827 and is also listed as coming from Cincinnati, Ohio. In the original description it is stated to be associated with *Pattersonia* about 350 feet above low water in the Ohio river. The type of *Chirospongia faberi* is here figured. It gives but little information regarding the structure of the sponge wall. Numerous, relatively thick, short striæ, regarded as spicules, from half to three-quarters of a millimeter long, traverse the surface longitudinally. These are arranged in quincuncial order, so as to produce the effect not only of longitudinal striation, but also of a sort of oblique striation. Locally, the thick longitudinal striations appear to be interwoven with much finer, apparently short, cross striations. While some of the latter striations make angles of about 60 degrees with the coarser longitudinal striations, this angle is not known to be constant, and the exact form of the spicules, whether three-rayed or six-rayed, can not be demonstrated from this type.

By Ulrich, the surface of *Leptopoterion mammiferum* was regarded as suggesting a net-work of overlapping hexactinellid spicules having the six rays spread in one plane, but the evidence is not conclusive.

6. **Protaraea vetusta,** Hall

(Plate II, Fig. 3)

1847. Porites ? vetusta Hall, Pal. New York, 1, p. 71, pl. 25, Figs. 5a, b.
1851. Protaraea vetusta Edwards and Haime, Ann. Sci. Nat., 3rd ser. Zool., 16 p. 47.
1899. Protarea vetusta Lambe, Cont. Canadian Pal. Geol. Surv. Canada, 4, pt. 1, p. 90, Plate 5, Figs. 8, 8a

The type of *Protaraea vetusta,* numbered 642, is preserved in the American Museum of Natural History, in New York City, and is labelled as coming from the Trenton at Watertown, New York. The number of corallites is about 5 in a length of 5 millimeters, sometimes equalling only about four and a half corallites in this distance. The surface of the type is badly weathered and the septa can not be traced beyond the immediate vicinity of the walls, though probably reaching half way toward the center of the calyces in well preserved specimens. The vertical tubules in the spaces between the corallites are fairly distinct under a lens. The specimen

consists apparently of a succession of lamellae, each from 1 to 2 millimeters in thickness, locally more or less free from each other.

Protaraea vetusta occurs in the cystid beds in the lower part of the Hull formation, in the Trenton, a short distance above water level on the eastern side of Nepean point at Ottawa, in Canada.

Lambe figures the tubules between the corallites in *Protaraea vetusta,* and Whiteaves, in his description of *Protaraea magna* clearly describes them. No tubules have been noticed in the spaces between the corallites of the Richmond species long correlated with *Protaraea vetusta,* but for which the name *Protaraea richmondensis* was proposed recently. In fact, I have long doubted whether the Richmond form even belonged to the same genus as the Trenton *Protaraea vetusta.* Both the calyces and the interspaces of the Richmond form are strongly papillose, and clearly defined septa are rare except in a few gerontic specimens.

The genotype of *Protaraea* is the Richmond, and not the Trenton form, as may be seen by consulting figures 6 and 6a on plate 14 accompanying the original description of the genus. (1851, Edwards and Haime, Mon. d. Polyp. Foss. d. Terr. Pal.)

7. **Calapoecia cribriformis,** Nicholson

(*Plate III, Fig. 5*)

1874. Columnopora cribriformis Nicholson, Geol. Mag., dec. 2, 1, p. 253

1875. Columnopora cribriformis Nicholson, Geol. Surv. Ohio, Pal. 2, p. 187, Plate 22, Figs. 8, 8a, 8b

1879. Columnopora cribriformis Nicholson, Tab. Corals Pal. Period, p. 164, Plate 7, Figs. 2-2d

The first figured specimen of this species (figure 8 in the Paleontology of Ohio) at present forms No. 216 in the James collection in the Museum at Chicago University, and a new illustration of this type is offered in the present bulletin. The same specimen was used also for figure 2 in Nicholson's work on the Tabulate Corals. The calyces of the corallites have circular, rather than polygonal outlines. According to Nicholson the origin of this specimen was: "In the Cincinnati Group (Hudson River Formation), near Cincinnati, Ohio (collected by Mr. U. P. James)." The expression "near Cincinnati," however, must be interpreted in a liberal sense, since the specimen almost certainly was obtained from the Richmond group of some part of Ohio, Indiana, or Kentucky, where it ranges from the Liberty to the Whitewater and Saluda members. In these

Cincinnatian areas, the corallites occasionally attain a diameter of 3 millimeters, but more commonly average between 2 and 2.3 millimeters. The tabulae rarely are well preserved; sometimes only the marginal parts, where attached to the walls of the corallites, are retained, but usually the tabulae have been entirely removed by weathering. About 7 to 10 tabulae occur in a length of 5 millimeters, occasionally increasing to 12 in this distance. The denticulate projections along the crest of the septal ridges rarely are well preserved. Judging from the small size of the figured type it is probable that it was obtained somewhere in Clinton or neighboring counties, in Ohio, where specimens are rare,and usually quite small.

The Canadian cotypes of *Columnopora cribriformis*, obtained, according to Nicholson "In the Hudson River Group, River Credit, Ontario (collected by Dr. G. J. Hinde)," were found at Streetsville, about 17 miles west of the center of Toronto. From Streetsville Junction a road leads northeast to the Credit river, and *Calapoecia* occurs west of the bridge, along the northern side of the river. The horizon corresponds approximately to the Whitewater as exposed in Ohio and Indiana. The Canadian cotypes from the Credit river were destroyed by the fire which burned up the Museum of the University of Toronto, years ago.

Both the Ohio and Credit river cotypes of *Columnopora cribriformis* evidently are specifically identical with *Calapoecia huronensis*, described by Billings (1865, Canadian Naturalist, volume 2, page 426) from the "Hudson River formation, Cape Smyth, Lake Huron." Cape Smith forms the most eastern part of Manitoulin island. The Richmond exposures occur at the Clay Cliff, about 4 miles south of the extremity of the cape. Here, as well as at numerous other localities on Manitoulin island, *Calapoecia huronensis* occurs both in strata corresponding to the Waynesville member as well as in those correlated with the Whitewater member of the Richmond.

Houghtonia huronica, described by Rominger (1876, Geol. Surv. Michigan, vol. 3, pt. 2, p. 18) from the "Hudson River group of Drummond's island, associated with *Columnaria stellata*," also is identical with *Calapoecia huronensis*. On Drummond island the Richmond exposures form the extreme northern margin of the island, extending in an east and west direction for about 5 miles. The specimens described by Rominger probably were obtained from strata corresponding to the Coral zone, in the lower part of the

Whitewater division of the Richmond, as identified on Manitoulin island.

Lambe (1899, Canadian Pal. Corals, pt. 1, p. 43) regards the Richmond specimens of *Calapoecia* from all of these localities as identical with *Calapoecia canadensis,* a form described by Billings (1865, Canadian Naturalist, vol. 2, p. 426) from the "Black River limestone near Ottawa." Here it was collected at the Paquette Rapids, on the Ottawa river. The Black River specimens of *Calapoecia* appear to have thinner corallite walls, the arrangement of the pores along horizontal lines appears more conspicuous, and the denticulations along the septal ridges appear more conspicuous, but Lambe is probably correct in failing to find any constant differences, of sufficient importance to be regarded as specific, between the Richmond and Black River forms. If it be desired to distinguish the Richmond forms from the latter, the term *Calapoecia huronensis* must be employed.

8. **Tetradium ontario,** Hall

1884. Tetradium ontario Hall, 35th Rep. New York State Mus. Nat. Hist., Plate 16, Fig. 9. (Figured but not described)

1888. Tetradium approximatum Ulrich, Amer. Geol., 1, p. 183 (Nomen nudum)

1915. Tetradium approximatum Bassler, Bibl. Index Am. Ord. and Sil. Fossils, Bull. 92, 2, U. S. Nat. Mus., p. 1264 (Numerous references to literature and published illustrations)

An excellent illustration of a cross section of *Tetradium ontario,* showing the form of the corallites in a very satisfactory manner, was published by Hall on a plate intended to illustrate the value of translucent sections in the study of corals. The origin of the specimen is cited as "Clinton group, shore of lake Ontario," but the specimen was an erratic one, colored reddish, derived from the basal part of the red Queenston clay shales north of the western end of Lake Ontario. Specimens of *Tetradium ontario* occur in situ at this horizon at the exposures along the small creek northeast of Oakville, about 20 miles southwest of Toronto, in the province of Ontario, in Canada, and it is evidently from this province that the type was obtained. The horizon at Oakville corresponds approximately to the base of the Coral zone at Streetsville, on the river Credit, about 10 miles directly north of Oakville. This horizon forms the base of those Canadian strata at present correlated with

the Whitewater member of the Richmond in Indiana and Ohio. The species ranges, however, from the lower part of the Waynesville member to the top of the Whitewater member, on Manitoulin island, and it occurs also in the fossiliferous layers near the middle of the Queenston clay shales, near Meaford, in Ontario. These Queenston shales are regarded as occupying the same time interval as the Whitewater member of the Richmond.

Ulrich prepared a monograph on the various species of *Tetradium*, but the plates were destroyed by fire and the monograph was never published. The only remnant of this monograph is the inclusion of the name *Tetradium approximatum* in his list of fossils from the Cincinnati Group, and the reference of this species to his beds XIII and XIV. His beds XIII include the Arnheim, Waynesville, and Liberty members of the Richmond, while beds XIV included the Whitewater and Elkhorn members. Evidently Ulrich regarded *Tetradium approximatum* as ranging through a considerable part, if not all, of the Richmond.

In my own collecting, in the Richmond of Cincinnatian areas, I have found *Tetradium* to range from the base of the Clarksville division of the Waynesville member of the Richmond to the top of the Richmond.

The term *Tetradium approximatum* evidently applies to the common Richmond form, which has a wide geographical range, both in the United States and in Canada. It can not be said, however, to have had any validity prior to the publication of Bassler's Index. It seems unfortunate that Hall's casual illustration of an erratic specimen should give priority to the term *Tetradium ontario*, but this actually is the case.

Dania huronica, described from Drummond island by Edwards and Haime (Mon. d. Polyp. Foss. Terr. Pal., 1851, p. 275, pl. 18, fig. 2, 2a. 2b) must be regarded for the present as a problematical species. Although usually assumed as of Niagaran age, the corallites are described as scarcely attaining a diameter of one millimeter even in the case of the largest corallites. No Niagaran coral is known from Drummond island with corallites of such small dimensions. Specimens of *Tetradium* however occur in the Richmond along the northern shore of the island, and occasionally the septa are rather distant and occur approximately at the same height across 6 to 20 of the exposed adjacent corallites.

9. **Dermatostroma papillatum,** James

(Plate I, Fig. 3)

1878. Stromatopora papillata James, Paleontologist, 1, p. 1
1910. Dermatostroma papillatum Parks, Univ. Toronto Studies, Geol. Series, 7, p. 30, Plate 23, Figs. 8-10

Specimens bearing the label, *Stromatopora papillata,* and numbered 1553, occur in the James collection, at Chicago University. They are labelled as coming from Ohio and Indiana. In two of these specimens, the growth incrusts valves of *Strophomena planumbona,* apparently from the Waynesville bed. Six or seven papillae occur in a length of 2 millimeters, measuring in the direction of the radiating striae of the *Strophomena.* In a third specimen growing upon *Strophomena sulcata,* presumably from the Waynesville or Liberty, seven papillae occur in a length of 2 millimeters, parallel to the radiating striae of the shell. Three additional specimens, bearing the same number, are regarded as belonging to *Dermatostroma glyptum* (Foerste), a species occurring in the Whitewater division of the Richmond.

The specimen illustrated in this bulletin was collected from the Clarksville division of the Waynesville member of the Richmond at Clarksville, Ohio, and is attached to a valve of *Byssonychia.* The granules tend to be arranged in rows parallel to the radiating plications of the *Byssonychia,* but toward the margin of the shell, where the plications are quite broad, the linear arrangement of the papillae is much less in evidence, indicating that this arrangement is dependent upon the character of the surface markings of the shell upon which the *Dermatostroma* grows. From 5 to 6 papillae occupy a length of 2 millimeters.

10. **Dermatostroma scabrum,** James

(Plate I, Fig. 4)

1879. Stromatopora scabra James, Paleontologist, 3, p. 18
1910. Dermatostroma scabrum Parks, Univ. Toronto Studies, Geol. Series, 7, p. 31, Plate 24, Figs. 1-3.

The cotypes of *Stromatopora scabra* were collected by Mr. W. H. Bean near Lebanon, Ohio; one from an horizon 10 to 20 feet below the large *Platystrophia ponderosa* (Mount Auburn) bed, and the other at a higher horizon. These horizons correspond evidently to the upper part of the Corryville member of the Maysville and to the Arnheim or Waynesville members of the Richmond respectively.

Dr. George M. Austin collected a typical specimen in the Waynesville member at Clarksville, Ohio (illustrated in this bulletin). Many of the monticules are abruptly conical, and fully one millimeter high. They are arranged more or less in series along the crests of the radiating plications of a *Byssonychia*, about 4 or 5 monticules occurring in a length of 10 millimeters. The papillæ also are arranged in series parallel to the plications, about 6 or 7 in a length of 2 millimeters. The incrustations of *Dermatostroma scabrum* usually are thicker than those of *Dermatostroma papillatum*. This raises the question whether *Dermatostroma scabrum* may not be merely the more mature form of *Dermatostroma papillatum*.

When attached to smooth surfaces, the monticules do not show any tendency toward arrangement in rows. There is no doubt, however, about the influence of the plications or narrow ridges of the supporting shells upon the arrangement of these monticules.

11. **Dermatostroma glyptum,** Foerste

(*Plate I, Fig. 2*)

1910. Labechia corrugata glypta Foerste, Bull. Sci. Lab. Denison Univ., 16, p. p. 87. (July 15)

1910. Dermatostroma corrugatum Parks, Univ. Toronto Studies, Geol. Series, 7, p. 33, Plate 24, Fig. 7. (October)

The type specimen, here figured, belongs to Dr. George M. Austin, and was found by him on Dutch creek, northwest of Wilmington, Ohio, in the upper part of the Whitewater member of the Richmond.

Papillæ coarse, varying greatly in number in different parts of the same specimen; usually from 3 to 4 in a length of 2 millimeters, but locally increasing to 6 in the same distance. In addition to papillæ there are ridge-like elevations, varying greatly in length. The shorter of these ridges consist of a uniserial line of papillæ, or of a more or less irregular agglomeration of papillæ, of larger height and width than the remainder, so united as to form short ridges or irregular elevations, and between the latter occur the ordinary papillæ. In addition to the shorter ridges, there are also longer ridges extending in a very irregular, vermiform manner across the surface, the ridges often crossing each other. These longer ridges occasionally have the appearance of being the limiting edges of separate individuals of the same species which have become attached to the

same host, and which interfere more or less at their points of contact. The specimens usually are incrusting on shells or other fossils. The type, by far the largest specimen known at present, is attached to the exterior of a large *Cameroceras*, 60 millimeters wide and 110 millimeters long. The thickness of the incrustation varies from less than a millimeter to fully 3 millimeters. The short ridges and irregular agglomerations noted above are regarded as the most characteristic feature of this species when typically developed, but in younger specimens these are not conspicuous and the coarser size of the papillæ is depended upon to distinguish it from *Dermatostroma papillatum* and *D. scabrum.* All specimens of *Dermatostroma glyptum* found so far occurred in the Whitewater member of the Richmond.

12. **Stromatocerium granulosum,** James

(*Plate I, Fig. 1*)

1865. Stenopora huronensis Billings (part), Geol. Surv. Canada, Pal. Foss., 1, p. 185

1875. Alveolites granulosus James, Cat. Foss. Cincinnati Group, p. 2

1883. Tetradium huronense Foord (part), Contr. Canadian Cambro-Sil. Micropal, p. 25, Plate 7, Figs. 1, 1a

1885. Labechia ohioensis Nicholson, Mon. British Strom., p. 32, Plate 1, Figs. 1, 2

1910. Stromatocerium huronense Parks, Univ. Toronto Studies, Geol. Series, No. 7, p. 20, Plate 22, Figs. 4-10, Plate 23, Fig. 5

A specimen of *Tetradium* encrusted with a thick growth of *Stromatocerium* served as the type of *Stenopora huronensis,* and the specimen was described by Billings as though the papillæ on the surface of the *Stromatocerium* were the terminations of the tubular corallites of the *Tetradium.* However, almost the entire description evidently is based upon the *Stromatocerium.* Foord redescribed the same specimen under the name *Tetradium huronense.* It is evident that he also regarded the surface features of the *Stromatocerium* as surface features of the *Tetradium,* and while he recognized the structure of the tubules at the center of the specimen as that of *Tetradium,* he did not differentiate that of the encrusting organism as *Stromatocerium.* In the meantime, however, James had described the same species from another locality, without any confusion of *Stromatocerium* and *Tetradium,* as *Alveolites granulosus.* The specimen described by Billings and Foord was obtained from the lower part of those strata on Manitoulin island, at Cape Smith, which correspond approximately with the Whitewater member

of the Richmond. The specimen described by James was obtained in the *Orthoceras fosteri* zone, at the base of the Clarksville division of the Waynesville member, at Clarksville, Ohio.

The type of *Alveolites granulosa,* figured in this Bulletin, is preserved in the James collection, at Chicago University, and is numbered 2250. It is not desired in this publication to revive the name used by James, in preference to *Stromatocerium huronense,* now generally accepted, but merely to offer a good illustration of the James type.

The interior structure of *Alveolites granulosa* is well presented by Prof. W. A. Parks (loc. cit. pl. 22, figs. 6, 10), and he figures also a second specimen from identically the same locality and horizon as this type (pl. 22, figs. 5, 8, 9). The specimen figured by Nicholson under the name *Labechia ohioensis* was obtained at Waynesville, Ohio, probably from the same part of the Waynesville member as the type of *Alveolites granulosa.* The structure of this species, therefore, may be said to be well known.

Under an ordinary magnifier, the type of *Alveolites granulosa* presents the appearance of a succession of papillose layers resting upon variable thicknesses of intermediate vesiculose tissue penetrated by vertical pillars. Frequently, on the weathered lateral surface of the specimen, the vertical pillars appear laminar, rather than filiform, and the vesiculose tissue presents the appearance of transverse tabulæ crossing the interior of narrow corallites. That this appearance is deceptive is shown by the transverse sections. The pillars usually grow in fascicles, each fascicle giving rise at the surface to a distinct mamelon, the pillars of the same fascicle spreading upward and outward from the center of the fascicle toward the surface of one of the mamellate elevations. Since the mamellate elevations of successive plates are not necessarily directly over each other, the spreading of these fascicles of vertical lamellæ at times is very irregular, those of different layers being inclined at different angles. In the original description by James this structure was noted in the following terms: "In some cases groups of corallites seem to radiate from different points or axes, and weathered sections show them as growing at various angles in the mass, shorter and longer and curving in different directions." It should be noted that this fasciculate structure is shown by vertical weathered sections, and that no reference is made here to the radiate arrangement

sometimes shown by the papillæ on the *surface* of the mamellate elevations.

13. **Stromatocerium montiferum,** Ulrich

(Plate II. Fig. 1)

1886. Labechia montifera Ulrich, Contr. to Amer. Pal., 1, p. 33, Fig. also Figs. 9 and 9a on plate 2, from a different specimen and horizon

The type of *Labechia montifera* was obtained at Madison, Indiana. It consists of a thin incrustation of *Stromatocerium*, locally 2 millimeters thick between the mamelons, elsewhere even thinner, growing upon a specimen of *Spyroceras hammelli* Foerste. This species of *Spyroceras* is not rare in the upper part of the Saluda at Madison, especially in the Hitz bed, and it occurs also at the same horizon at the Dog Falls, west of Hanover. It occurs also in lower parts of the Saluda member of the Richmond at various localities in southeastern Indiana, and probably ranges through most of the Richmond, since typical specimens are not rare in the Waynesville member of the Richmond on Manitoulin island, in Lake Huron. It may be regarded as practically certain, however, that the type of *Labechia montifera* was obtained in the upper part of the Saluda at Madison, since thin growths of *Stromatocerium* often occur on the specimens of *Spyroceras* found there, and this is the only horizon at Madison at which *Spyroceras* has been found.

The surface of the type specimen is covered with papillæ, usually from 5 to 6 in a length of 2 millimeters, where the papillæ are best preserved, but varying locally from as low as 4 to as high as 8 in the same length. The number of mamelons varies from 5 in a length of 20 millimeters to about 4 in the same length. Some parts of the incrustation are fully 2 millimeters thick in the spaces between the mamelons. Along one side of the specimen the mamelons are low and rather indistinct, but elsewhere they are sharply defined.

The type specimen bears no evidence of having been sectioned, but the original description is accompanied by figures of a specimen from Waynesville, Ohio, which present vertical and transverse sections of the latter.

These sections indicate clearly that the Waynesville specimen, at least, can not be differentiated from typical *Stromatocerium huronense.* The occurrence of thin films of *Stromatocerium* on *Spyroceras* at Madison does not in itself indicate a distinct species,

since much thicker growths occur there also in the same horizon, some of them several inches in thickness. In fact, *Labechia montifera* appears to be identical with *Stromatocerium huronense.* At least, if distinct, the distinguishing characteristics have not yet been noted.

The type of *Labechia montifera* is in the possession of George K. Greene, of New Albany, Indiana.

14. **Stromatocerium indianense,** James

1892. Stromatopora indianensis James, Jour. Cincinnati Soc. Nat. Hist., 15, p. 92

The type of *Stromatopora indianensis* was a characteristic specimen of *Stromatocerium huronense* from the *Beatricea nodulosa* horizon in the Elkhorn member of the Richmond, at Longwood, five and a half miles west of Connersville. At this locality, *Stromatocerium,* associated with *Tetradium,* is common about 70 feet below the exposures of the Laurel limestone division of the Silurian. On Elkhorn creek, three miles southeast of Richmond, Indiana, *Stromatocerium* occurs immediately below the Brassfield limestone member of the Silurian, also 11 feet lower, and *Beatricea* is found both at 14 and at 29 feet below the Brassfield. In fact, both *Stromatocerium* and *Beatricea* range throughout the Elkhorn member, although usually confined at each locality to only one or two horizons.

The type of *Stromatocerium indianense* had the characteristic large and prominent mamellate elevations of the Richmond species, *Stromatocerium huronense.* It was a massive specimen 8 inches long, 6 inches wide, and 5 inches high. It can no longer be found among the specimens preserved in the U. S. National Museum, but there is no doubt as to identity of the species.

15. **Stromatocerium huronense australe,** Parks

1910. Stromatocerium huronense australe Parks, Univ. Toronto Studies, Geol. Series, No. 7, p. 24, Plate 22, Fig. 11

Stromatocerium huronense australe was described from a series of Kentucky Richmond forms belonging to the Ulrich collection, deposited in the U. S. National Museum, at Washington; but the only figured specimen, also from the Ulrich collection, was obtained in the Leipers division of the Maysville, near Nashville, in Tennessee. Ignoring the Richmond forms, Bassler, in his Bibliographic Index

(Bull. 92, U. S. Nat. Mus. Vol. 2, p. 1213, 1915) lists the Leipers form as the holotype.

The Richmond specimens mentioned in the original description were obtained at three localities: Upper Richmond, near Lebanon, Ky.; top of Cincinnati Group, 18 miles east of Louisville, Ky.; and Upper Richmond, eastern part of Jefferson county, Kentucky.

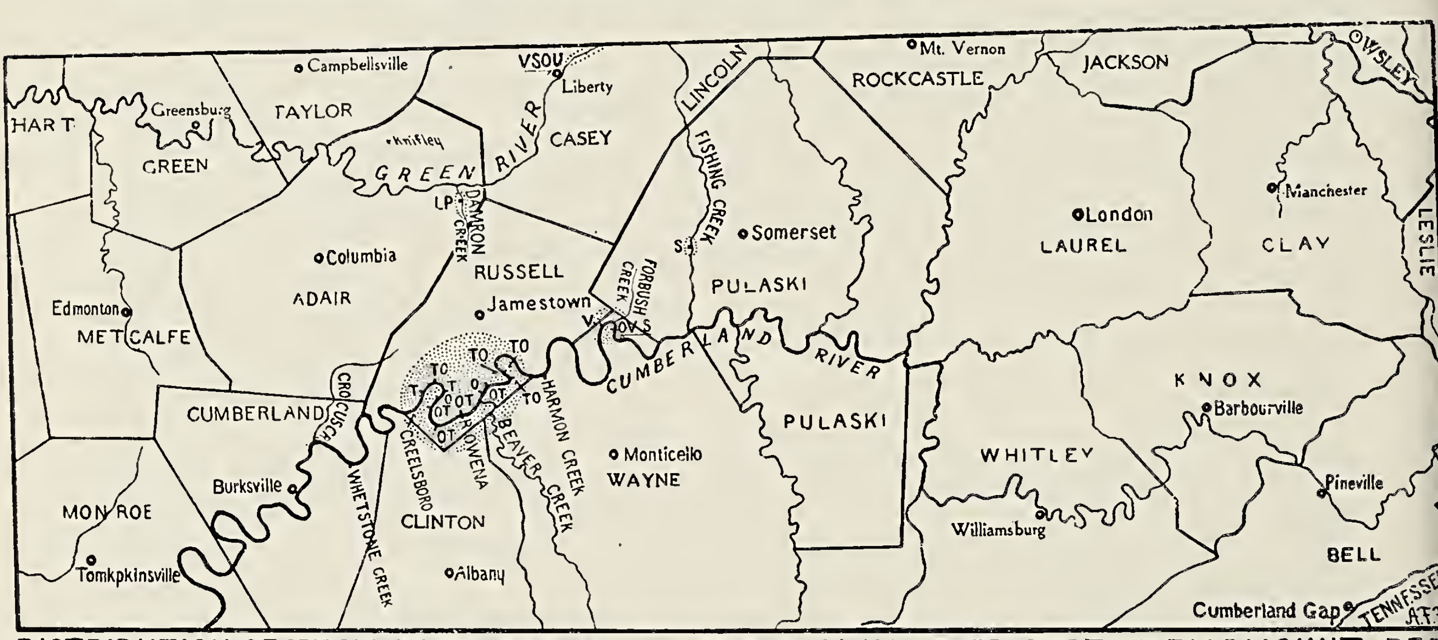
In the area west of the Cincinnati geanticline in Kentucky, *Stromatocerium* is known at only two horizons in the Richmond. One of these is at the top of the Saluda member, but below the Hitz layer, when the latter is present. The second horizon includes the great coral reef at the base of the Liberty member, and extends from a short distance below this reef to a short distance above the latter. There is no reason why *Stromatocerium* should not occur also in the Coral reef in the lower part of the Waynesville member, since it is usually associated with one or more species of the massive corals, and is known to occur as low as the base of the middle or Clarksville division of the Waynesville at various localities in Ohio. In south-central Kentucky, at various localities in Clark, Madison, and Garrard counties, *Stromatocerium* is found in the upper half of the Arnheim, above the *Dinorthis carleyi* horizon; and at Wyoming, in the southern edge of Fleming county, it occurs at the base of the *Platystrophia ponderosa* horizon which there appears to correspond approximately to the position of the Mount Auburn member of the Maysville, if this member extends that far southeastward. As a matter of fact, however, *Stromatocerium* is unknown at present from any of these lower horizons in any part of the area west of the Cincinnati geanticline, in Kentucky.

I am unable to distinguish any of the Richmond specimens of *Stromatocerium* found in any part of the area west of the Cincinnati geanticline, between Lebanon and Louisville, from the typical forms of *Stromatocerium huronense,* as found at the type locality, the Clay Cliff, south of Cape Smith, on the eastern shore of Manitoulin island. Even at the type locality there is great variation in the prominence and angularity of the mamelons, and in the distance between the latter. That corresponding differences are seen in the Kentucky specimens is indicated by the reference of specimen No 39488, from the Upper Richmond a mile and a half west of Lebanon, Kentucky, to the typical form of *Stromatocerium huronense* (Parks, loc. cit. p.24).

I have often wondered, however, whether it might be possible, on minute examination, to distinguish the Leipers form of *Stromato-*

cerium from that characteristic of the Richmond. It was the Leipers form, from the vicinity of Nashville, which was figured by Parks as an illustration of his *Stromatocerium huronense australe*, and this is the specimen listed by Bassler as the holotype.

In Kentucky, *Stromatocerium* is known from the Leipers division of the Maysville only from the Cumberland river exposures, between Harmon creek and Creelsboro, in the southern part of Russell county. Here it is associated with *Tetradium fibratum, Escharopora hilli, Strophomena maysvillensis, Orthorhynchula linneyi*, and *Cyrtoceras vallandinghami*, a typical Leipers fauna. This Leipers fauna extends northeastward into Marion, Boyle, Garrard, and Madison counties, but farther northward apparently merges into the upper part of the Fairmount member of the Maysville, and only a few of the characteristic species reach the Ohio river.



DISTRIBUTION OF STROMATOCERIUM AND TETRADIUM IN UPPER PART OF FAIRMOUNT BED. COLUMNARIA VACUA, STREPTELASMA, STROMATOCERIUM, AND BEATRICEA UNDULATA IN RICHMOND.

In the accompanying sketch map, indicating these exposures of the Leipers member of the Maysville, along the Cumberland river in Kentucky, at which *Stromatocerium* was found, several interesting Richmond localities also are noted. In the northern part of Wayne county, opposite the mouth of Forbush creek, *Stromatocerium* was found associated with *Columnaria vacua* and *Streptelasma rusticum*. The *Streptelasma* was found also on Fishing creek, in Pulaski county, along a road leading west from Somerset.

Stromatocerium occurs also north of the road from Liberty to Hustonville, on the northern side of Green river, nearly 2 miles

northeast of Liberty, in Casey county. Here the following interesting section is shown:

New Albany Black shale	1 ft.
Greenish clay over phosphatic sandy layer, regarded as the base of the Devonian exposures here	6 in.
Argillaceous rock, cracking into rubble, unfossiliferous, regarded as equivalent to the Saluda member of the Richmond	27 ft. 6 in.
Calcareous strata with *Tetradium* abundant and massive, and with a few specimens of *Stromatocerium*	1 ft. 2 in.
Blue limestone with *Platystrophia* and *Hebertella sinuata*	10 in.
Calcareous strata with *Columnaria vacua* and *Beatricea undulata*	1 ft.
(The overlying fossiliferous strata are regarded as equivalent to the coral zones in the lower part of the Liberty member in Marion county, and farther northward.)	
Argillaceous strata, unfossiliferous, regarded as approximately equivalent to the Waynesville member of the Richmond, the base of this member being not exposed here	30 ft.

A small exposure of the Arnheim member of the Richmond, containing *Leptaena richmondensis precursor,* is indicated on Damron creek, in the northeastern part of Adair county. *Platystrophia ponderosa* occurs at a lower horizon in strata regarded as equivalent to the upper part of the Maysville. The *Leptaena* occurs within 12 inches of the base of the Devonian limestone which here intervenes between the top of the Arnheim and the base of the New Albany Black Shale, so that only the basal part of the Richmond is preserved here.

16. **Lingula covingtonensis,** Hall and Whitfield

(*Plate III, Fig. 7*)

1875. Lingula covingtonensis Hall and Whitfield, Pal. Ohio, 2, p. 67, Plate 1, Fig. 1
1910. Lingula covingtonensis Foerste, Bull. Sci. Lab. Denison Univ., 16, p. 22, Plate 5, Fig. 5

The type of *Lingula covingtonensis,* numbered 139 in the James collection at Chicago University, was figured, enlarged, in the Bulletin of Denison University, cited above. The type presents the interior of the upper valve, partly exfoliated. It is labelled as coming from Kentucky, opposite Cincinnati, and was obtained in the upper part of the Cynthiana formation, in strata described by Orton as the River Quarry beds.

These River quarry beds are not identical with the Point Pleasant beds of Orton. At the time Orton defined his Point Pleasant beds,

the *Triarthrus becki* horizon, immediately overlying the River quarry beds, opposite Cincinnati, was well known and the same horizon, is typically exposed at Point Pleasant. Below this *Triarthrus becki* horizon, both at Cincinnati and at Point Pleasant, occurred coarse-grained layers of limestone containing apparently the same species of *Trinucleus concentricus* as that occurring in the strata overlying the *Triarthrus becki* horizon. At Point Pleasant there were hill quarry beds as well as river quarry beds. The former included chiefly the strata extending between 75 and 115 feet above the water level, and the latter extended along the immediate edge of the river and were worked chiefly at low water, although locally rising to about 15 feet above the water's edge. This explains Orton's statements in his original definition of the Point Pleasant beds (Ohio Geol. 1, 1872, p. 370):

"—— the river quarries in the central portions of Clermont county, which lie a dozen miles south of Cincinnati, disclose rocks that underlie by at least 50 feet the lowest beds at Cincinnati. The locality at which these lowest rocks of the State present the best exposures and clearest section is Point Pleasant, and this division can accordingly be named the *Point Pleasant beds.* Its boundaries have been already assigned by implication; these beds beginning at low water mark at Cincinnati, and descending until they include the lowest rocks exposed in the State."

17. **Lingula vanhornei,** Miller

(*Plate III, Fig. 6, Plate IV, Fig. 5A, B*)

1875. Lingula vanhornei Miller, Cincinnati Quart. Jour. Sci., 2, p. 9, Fig. 1

The type of *Lingula vanhornei,* numbered 8865, in the Faber collection at Chicago University, is an entire shell, partly exfoliated. The illustration accompanying the original description represents the pedicel valve, and this valve is illustrated also in the present bulletin.

The species appears more closely related to *Lingula procteri* Ulrich, as illustrated by Hall and Clarke (Pal. New York, 8, pt. 1, pl. 1, figs. 5, 6), than to the group of species typified by *Lingula cincinnatiensis,* of which *Lingula iowensis* is a member. In *Lingula iowensis,* the brachial valve is characterized by a bold, sharp median septum, terminating abruptly a considerable distance anterior to the concrete laterals, of Hall and Clarke. No such conspicuous

median septum is indicated by the type of *Lingula vanhornei.* Here the concrete laterals are rather weakly defined, and their anterior margin extends to a distance of nearly 11 millimeters from the beak, the entire length of this brachial valve being 17 millimeters. Between these concrete laterals there is an ill-defined linear space, about half a millimeter in width anteriorly, obscurely elevated at the lateral margins, and this linear space extends anterior to the concrete laterals as far as the anterior part of the vascular trunks, of Hall and Clarke. These vascular trunks are within 1.5 mm. from the margin of the shell at a distance of 11 mm. from the beak, and curve around anteriorly so as to reach within 1.7 mm. of the front margin of the shell. In their curvature, these vascular trunks of *Lingula vanhornei* closely resemble those of *Lingula elderi,* as figured by Hall and Clarke. Faint traces of vascular branches extend from the vascular trunks toward the antero-lateral and anterior margins of the shell, as in *Lingula elderi,* but there are no traces of vascular branches extending from the vascular trunks toward the concrete laterals.

The general shape of the muscular area of the pedicel valve of *Lingula vanhornei* also is similar to that of *Lingula procteri.* In general this shape may be defined as broadly cuneate with a very divergent V-shaped anterior margin along which the interior of the shell is moderately thickened and from which radiate vascular branches. The narrow, almost linear area, between the concrete laterals forming the major part of this muscular area, is not clearly defined. The vascular trunks of the pedicel valve pursue essentially the same directions as those of the brachial valve, and from these trunks the vascular branches may be traced toward the antero-lateral and anterior margins of the shell, but the vascular branches between these vascular trunks and the anterior margin of the concrete laterals appear to radiate from the anterior margin of the latter toward the vascular trunks, of Hall and Clarke, and do not appear to have their origin in these trunks and to extend from the trunks toward the concrete laterals, as in the figures presented by these authors in the case of *Lingula elderi.*

The length of the type is 18 mm. the beak of the pedicel valve extends almost a millimeter anterior to that of the brachial valve. The width of the shell is 11 mm. The thickness from valve to valve is 4.5 mm. The outline is oval oblong. The type was found at Versailles, Indiana, and probably came from the Waynesville member

of the Richmond group. The species however makes its appearance already in the Arnheim. About a mile south of Milton, Kentucky, along the road to Bedford, a specimen referred to this species was found 11 feet above the *Dinorthis carleyi* horizon, and 13 feet below the lowest strata containing *Strophomena planumbona* and *Dalmanella jugosa.*

18. **Lingula brookvillensis,** n. sp.

(*Plate IV, Figs. 6 A, B*)

A medium sized *Lingula,* found at Boundary Hill, about two miles west of Brookville, in Indiana, closely resembles *Lingula cincinnatiensis* Hall and Whitfield in its internal features. *Lingula cincinnatiensis* is characteristic of the Fairmount division of the Maysville group, in Ohio, Indiana, and Kentucky, and a form not to be distinguished from this species occurs in the Rogers Gap member of the Cynthiana group, about one mile north of Rogers gap, in Kentucky. *Lingula rectilateralis* Emmons, from the Utica and Trenton of New York, and *Lingula iowensis* Owen from the Trenton of Wisconsin, Iowa, Minnesota, Illinois, and Manitoba, are closely related to, and almost identical with *Lingula cincinnatiensis.* All of these species belong to the group, typified by *Lingula quadrata* Eichwald, for which the term *Pseudolingula* was proposed by Mickwitz, in 1909. As defined by Schuchert *Pseudolingula* is characterized by a ventral pedicel groove and a pair of umbonal muscles, features ordinarily not likely to be exposed.

From the species mentioned above, the Brookville specimen differs conspicuously in its smaller size. The length of the brachial valve is 15.5 mm., the width is 9.5 mm., and the thickness from valve to valve is about 3.4 millimeters. The beak of the pedicel valve extended at least half a millimeter beyond that of the brachial valve. The sides of the shell are subparallel for a length of about 7 mm., and then curve posteriorly into the postero-lateral margin, which forms an angle of about 140 or 145 degrees with the lateral margin. The beak of the brachial valve is rather narrowly rounded. The anterior margin of the shell is moderately convex, rounding rather strongly into the lateral margins, producing a quadrangular outline very similar to that of *Lingula cincinnatiensis,* but distinctly more elongated.

Along the middle parts of the shell, between two imaginary lines extending from the beak to the antero-lateral angles, the valves

are moderately convex. From these lines, the surface slopes rather strongly toward the postero-lateral angles, being more or less concave near the margin of this part of the shell. Along the median part of the brachial valve the shell is faintly elevated anteriorly, the elevation being separated from the antero-lateral parts of the valve by broad, shallow, almost obsolete depressions, also following directions radiating from the beak; these depressions are about 4 millimeters apart at the anterior margin of the valve. There is a slight tendency toward a median elevation also on the pedicel valve, but this elevation has a width of scarcely 2 millimeters. The surface of the shell is marked by fine concentric lines, often 15 in a length of one millimeter. Fine radiating lines traverse the shell, especially along the moderately convex median parts, included between the imaginary lines leading from the beak to the antero-lateral angles; within this space the radiating lines usually number about 8 in a width of one millimeter.

The interior of the brachial valve is characterized by a long median septum, extending nearly 11 millimeters forward from the beak, and attaining its greatest width and elevation within one millimeter of the end, where its width is 1.2 mm., and its elevation 0.8 mm. Two narrowly cuneate very shallow depressions extend forward for a distance of 7 mm. from the beak, one on each side of the septum, attaining a width of about 1.2 mm. at their anterior ends. At their anterior ends these cuneate depressions are limited quite distinctly by moderately elevated crescentic elevations extending laterally from the median septum for a greater distance than the cuneate depressions themselves. The crescentic elevations and the narrowly cuneate depressions correspond to the central scars and the concrete laterals of Hall and Clarke, as figured by them in case of *Lingula iowensis* (Pal. New York, 8, pt. 1, 1892, pl. 1, fig. 14). On each side of this pair of concrete laterals there is an additional very faint depression, similar to the pair figured by Hall and Clarke in case of *Lingula iowensis*, but much less distinctly defined. This pair extends forward from the beak a distance of about 5.5 mm., and also attains a width of slightly more than a millimeter, and is limited by a slight elevation anteriorly. Both pairs of shallow cuneate depressions apparently are due to the areas of attachment of muscles which enlarge and shift toward the front with advancing age. Of these areas of attachment there are four, the final location of which is indicated by the crescentic elevations

at the anterior ends of the four cuneate depressions. The cuneate depressions themselves merely indicate the successively advancing former locations of these areas of attachment.

The markings on the interior surface of the pedicel valve may be compared most readily with those figured by Hall and Clarke (loc. cit. pl. 1, fig. 6) in the case of *Lingula procteri* Ulrich, from the upper part of the Cynthiana group, at West Covington, Kentucky. The muscular area extends forward from the beak a distance of 7.5 mm. terminating at the crest of a crescentic callosity crossing the valve transversely near midlength of the shell. From this crest the anterior side of the callosity slopes forward for a distance of 0.6 mm. to the general level of the interior of the valve. Between imaginary radiating lines extending from the beak forward to the antero-lateral angles of the shell, the muscular area is distinctly flattened, this flattened area reaching at its anterior margin a width of 4 mm. Along the median line of this flattened area the surface is slightly elevated, the nearly obsolete cuneate elevation attaining a width of about 0.8 mm. at its anterior margin. The muscular area intrudes for a slight distance, beyond the flattened part, upon the postero-lateral concave part of the interior of the valve. Vascular markings extend from the ridge along the top of the crescentic transverse callosity forward down the anterior slope of the callosity and then along the general interior surface of the valve for a total distance of 2 mm. from the apex of the ridge of the callosity, near the median parts of the shell, becoming successively shorter laterally. Their direction is approximately perpendicular to the curvature of the anterior margin of the muscular area. Similar vascular markings are found in *Lingula vanhornei*, a shell having an outline very similar to that of *Lingula procteri*.

It is not at all improbable that *Lingula brookvillensis* is closely related to *Lingula bisulcata* Ulrich, from the Economy member of the Eden group at Ludlow, Kentucky. *Lingula bisulcata* is a distinctly shorter and broader shell, and the median septum of the brachial valve is much shorter. There is, however, a similar general outline. There is also a similar faint elevation of the median parts of the exterior of the valve, bounded by faint radiating depressions on each side, as in *Lingula brookvillensis*, but no special significance is attached to the latter features since they appear to be quite frequent, although often obsolete in various individuals of the same species, among the quadrangular forms of *Lingula*.

The chief characteristics of *Lingula brookvillensis* are its medium size, rather elongate quadrangular outline, and the thinness of the valves excepting where thickened by callosities. The horizon appears to be near the base of the Richmond group, probably within the Arnheim member.

19. **Trematis crassipunctata,** Ulrich

(*Plate VI, Fig. 6*)

1889. Trematis crassipunctata Ulrich, Amer. Geol., 4, p. 22; 3, p. 378, Fig. 7

The types of *Trematis crassipunctata,* including the specimen figured by Ulrich, belong to the collection of Prof. Charles Schuchert, of Yale University. The species was described from the Fairmount member of the Maysville group at Cincinnati, Ohio.

The type figured by Ulrich is 15.5 mm. in length and 16 mm. in width. It is preserved in clay shale, and at present is rather flattened, but originally it probably had a convexity of 2.5 mm. About 90 radiating striations may be counted at the margin of the shell, but of these only about 50 are present within a radius of 5 mm. from the beak. Along the median parts of the shell anteriorly 5 interspaces, between the radiating striations, occur in a width of 1.7 mm., and the almost rectangular pits here number 5 in a length of 1.6 mm. Along the antero-lateral margins the pits are larger, numbering 5 in a width of 2.8 mm., and 5 in a length of 2.4 mm. In this type specimen, the radiating striations and pits may be traced to the beak.

In the second specimen, accompanying the figured specimen, and labelled as coming from the vicinity of the Lookout House at Cincinnati, Ohio, there are no pits within a distance of 4 mm. from the beak. At first the interspaces between the pits are relatively wide, but become narrow anteriorly, especially beyond 8 mm. from the beak. Along the antero-lateral parts of the shell there are 5 pits in a width of 2 mm., and 5 pits in a length of 1.6 mm.

This species is distinguished chiefly by the large size of the pits between the radiating striæ, and by their strongly quadrangular appearance.

20. **Trematis fragilis,** Ulrich

(*Plate III, Fig 12*)

1873. Trematis punctostriata Hall and Whitfield, Pal. Ohio, 2, p. 70, Plate 1, Fig. 9

1910. Trematis fragilis Foerste, Bull. Sci. Lab. Denison University 16, p. 38, Plate 5, Fig. 2)

The shell here figured is numbered 102 in the James collection at Chicago University. It was found at Cincinnati, Ohio, but the

horizon from which it was obtained is not known with certainty. It was identified by Hall and Whitfield with *Trematis punctostriata,* but that this was an error was pointed out by Schuchert long ago. It is referred with some doubt to *Trematis fragilis* (Ulrich, Amer. Geol., 4, 1889, p. 21, 3, p. 378, fig. 6.) on account of its rotund outline and the general absence of pits over the greater part of the shell excepting along the postero-lateral margins.

The specimen used for figure 8, on plate 1, in the second volume of the Paleontology of Ohio, cited above, appears to be preserved in the American Museum of Natural History, in New York City, where it is numbered 1335-2. The anterior outline of this specimen is more rounded than in the published figure, although the specimen is slightly wider than long. The punctæ are distinct only posteriorly, near the beak, and thence along the margin of the shell as far as the antero-lateral part of the shell. The remainder of the shell is smooth. If the anterior margin of the shell were as moderately convex as figured, this specimen could be identified as *Trematis oblata* Ulrich, but the more rounded anterior margin favors *Trematis fragilis.*

Craniae of the Richmond Group

The Cranias of the Cincinnatian series of rocks offer interesting examples of the influence of the form of supporting surfaces upon the form of closely sessile species. Often even the more minute irregularities of the supporting surface are reproduced in the upper valves of the Cranias.

In such a form as *Crania scabiosa,* the margin of the upper valve is closely applied to the supporting surface, curving up and down on crossing each plication or striation. As the *Crania* enlarges in size, the earlier margins of the upper valves are lifted from the supporting surface and later margins of these valves extend outward. In this manner the details of ornamentation of the supporting surface often are reproduced by the surface of the upper valve of the *Crania* with *remarkable* accuracy of detail. This fact has been known long enough to place such supposed species as *Crania multipunctata, Cr. costata, Cr. asperula,* and *Cr. alternata* among the synonyms of *Crania scabiosa.* The object in calling attention here to these so-called species is not to revive the names once suggested for them, but to place on record what the types suggesting these names actually were, and to let this record stand as an interesting example of the

influence of the form of supporting surfaces upon the form of closely sessile species, such as the Cranias here under discussion.

Similar examples occur among the Cranias found in the Eden group, in the vicinity of Cincinnati, and for these also distinct specific terms were suggested in times past. There is a tendency to include these also as synonyms under *Crania scabiosa*, but a close study of the types of the Eden forms suggests at least the possibility of some of the latter belonging, at least in part, to a distinct species.

21. **Crania scabiosa,** Hall

1868. Crania scabiosa Hall, Descriptions n. sp. Crinoidea and other Foss., p. 13

1872. Crania scabiosa Hall, 24th Rep. New York State Cab. Nat. Hist., p. 220, Plate 7, Fig. 15

1892. Crania scabiosa Hall and Clarke, Pal. New York, 8, pt. 1 p. 148, Plate 4 H, Figs. 23-28, 30, 31

The first figured specimen of *Crania scabiosa* (24th Rep. New York State Cab. Nat. Hist.), here regarded as the type of the species, consisted of a group of individuals attached to *Platystrophia ponderosa,* and evidently was obtained from the upper part of the Maysville group, at Cincinnati, Ohio. The individuals are robust, thick shells, and although conforming to the plications of the supporting *Platystrophia,* they retain also very well the strong concentric lamellose markings which suggested the specific term *scabiosa.* In another specimen, also from Cincinnati, Ohio, and figured by Hall and Clarke (Pal. New York, 8, pt. 1), about thirty individuals, supported upon the brachial valve of *Rafinesquina alternata,* reproduce the radiating striations of the latter distinctly.

Crania scabiosa is abundant also in the Richmond group, especially in the Waynesville member.

22. **Crania multipunctata,** Miller

(*Plate III, Figs. 13 A, B*)

1875. Crania multipunctata Miller, Cincinnati Quart. Jour. Sci., 2, p. 13, Fig. 4

The type of *Crania multipunctata,* numbered 8869, in the Faber collection at Chicago University, is a thin upper valve, 7.5 mm. long, 8 mm. wide, and about 1.5 mm. high. The posterior outline is comparatively straight, and the apex of the valve appears to have been close to this margin, but no traces of concentric or radiating

striæ are seen. The specimen, during life, evidently rested upon some bryozoan, the cells of which have been reproduced to some extent in the surface strcture of the upper valve. Of these cells there were 8 in a length of 2 mm., and these cells were arranged in rows crossing each other diagonally. They are best preserved on the right side of the specimen and near the posterior margin.

Crania multipunctata was described as coming from near the upper part of the hills at Cincinnati, Ohio, and presumably was found in the Corryville member of the Maysville.

23. **Crania costata,** James

(*Plate III, Fig. 15*)

1879. Crania costata, James, Paleontologist, 3, p. 22)

The type of *Crania costata* is preserved in the Welch collection in the college at Wilmington, Ohio. In its younger stages of growth it evidently was attached to some brachiopod with strong radiating plications, or possibly to some *Byssonychia.* These radiating plications have left their impress upon the *Crania,* traversing the latter in only one direction, and not radiating from the apex of the valve, as in *Crania laelia* and *Crania albersi.* At present, the valve is attached to a fragment of shale. The specimen evidently was obtained from some part of the Richmond, but the exact horizon is unknown.

24. **Crania asperula,** James

(*Plate III, Figs. 9 A B*)

1879. Crania asperula James, Paleontologist, 3, p. 22

The type of *Crania asperula* is preserved in the Welch collection deposited in the college at Wilmington, Ohio. The fragment of rock to which the Crania is attached shows traces of *Hebertella insculpta, Bythopora delicatula,* and *Helopora harrisi,* and evidently was found in the *Hebertella insculpta* layer at the base of the Liberty member of the Richmond, at Clarksville, Ohio. In its earlier stages at least it was attached to the upper part of the brachial valve of a *Hebertella insculpta,* near the beak, and both the radiating plications, and the much finer transverse striations of this shell have left their impress upon the *Crania.* The latter is regarded merely as an interesting example of *Crania scabiosa* Hall.

25. **Crania alternata,** James

(Plate III, Figs. 10 A, B

1879. Crania alternata James, Paleontologist, 3, p. 23

The type of *Crania alternata,* numbered 1557, is preserved in the James collection, at Chicago University. The width of the shell is 9.5 millimeters; the length, 8 millimeters; and the height, 2.2 millimeters. The upper valve is marked by vertical costæ or striations, due to the radiating plications of the shell upon which this *Crania* grew. Fine, concentric striæ also are present.

The specimen was found near Blanchester, Ohio, probably in the upper or Blanchester division of the Waynesville member of the Richmond, and is regarded merely as one of the many specimens of *Crania scabiosa* which give indications of the surface markings of the shells upon which they grew. The type consists of an upper valve, no longer attached to the shell on which it grew during life, but resting upon the upper surface of a rock fragment containing traces of the former presence of *Leptaena richmondensis,* in addition to better preserved remains of other fossils.

Craniae from the Economy member of the Eden Group

Five species of *Crania* have been described from the Economy member of the Eden group. In their order of publication these species are: *Crania dyeri, Cr. percarinata, Cr. parallela, Cr. socialis,* and *Cr. albersi.* Of these, *Crania dyeri* is characterized by sharp concentric striæ, giving the shell an orbiculoid appearance. *Crania albersi* is characterized by sharp, fine, closely set radiating striæ.

This leaves three species, *Crania percarinata, Cr. parallela,* and *Cr. socialis* which were distinguished originally by features which characterized the shells upon which the Cranias rested, rather than Cranias themselves, since these features were merely reproduced by the Cranias and did not originate with the latter. In searching for features which might be regarded as characteristic of the Cranias it was discovered that among the types of each of these three so-called species there were shells on which granules were present. These granules tend to be elongated in a radial direction, somewhat as in *Crania setigera* from the Trenton of Wisconsin, Iowa, and Minnesota, but they are much more minute than in that species. It would be easy to combine the three so-called species here discussed into a single species characterized by the presence of very minute, radially

elongated granules, if these granules always were present, but the problem is complicated by the failure of these granules to appear in relatively numerous other specimens, otherwise indistinguishable from this group. There is a tendency to regard these species as identical with *Crania scabiosa,* originally described from the Richmond, but the latter do not possess the radially elongated minute granules. I am inclined to regard the Eden group specimens with the minute radiately elongated granules as sufficiently distinct from *Crania scabiosa* when present in large numbers, in which case the chances of detecting the radiately elongated granules are very favorable, but it is quite evident, from the material already examined, that these features can not be depended upon as diagnostic for all specimens, since in relatively numerous specimens they have not been found. Since the term *Crania percarinata* appears first in the publication in which the three so-called species here discussed were described, this name might be used to include at least all of those specimens in which the radiately elongated minute granules can be detected.

Crania socialis is known only attached to crinoid stems. On these supports the shells could not develop symmetrically. Growth in a direction transverse to the length of the crinoid stem was especially restricted, but this retarded growth to a certain extent also in a direction parallel to the length of the crinoid stem. As a result, the shell of *Crania socialis* appears not only abnormally elongated but also abnormally thickened. The fact that the apex in some specimens appears near one end of the elongated shell, and in other specimens near the middle of one of the sides suggests that the elongation is due to the character of the support and has no specific value. It, therefore, appears to me to differ from those specimens of *Crania percarinata* and *Crania parallela* which have radiately-elongated granules only in features dependent upon the form of the support which they accidentally chose.

Detailed description of the types are given on the following pages.

26. **Crania dyeri,** Miller

1875. Crania dyeri Miller, Cincinnati Quarterly Jour. Sci., 2, 13, Fig. 3

The type of *Crania dyeri* is numbered 1758 in the Dyer collection at Harvard University. It is cited by Bassler, in his Bibliographic Index of American Ordovician and Silurian Fossils, only from the

Economy member of the Eden group, at Cincinnati, Ohio. The length of the type is 5 mm., the width is only slightly less, and the height is about 1.7 mm. The apex is about two-fifths of the length of the shell from the posterior margin, so that the concentric striæ are crowded posterior to the apex. The concentric striæ are thick, strong, and salient for a shell of such small size. The prominence of the striæ becomes gradually less from the margin toward the apex. The exterior three are strong, the next three vary from medium to fine, and the last three, toward the apex, are almost obsolete in the type, but this may be due in part to wear.

A second specimen, in the Dyer collection, is slightly larger, and is marked by 12 concentric striæ. The outer striæ in this specimen are not so strikingly larger and coarser than those nearer the apex as in the type specimen.

27. **Crania percarinata,** Ulrich

(Plate VI, Fig. 1; Plate IV, Fig. 7)

1878. Crania percarinata Ulrich, Jour. Cincinnati Soc. Nat. Hist., 1, p. 98, Plate 4, Fig. 12

1892. Crania percarinata (=Crania scabiosa Hall) Hall and Clarke, Pal. New York, 8, pt. 1, Plate 4H, Fig. 30

The types of *Crania percarinata* belong to the collection of Prof. Charles Schuchert, of Yale University, and were found in the Economy member of the Eden, about 100 feet above low water in the Ohio river, at Covington, Kentucky.

The specimen illustrated by figure 30, in the Hall and Clarke publication cited above (fig. 1 on plate VI and fig. 7 on plate IV of present bulletin), is 3 mm. in length, 4.1 mm. in width, and has a convexity slightly exceeding one millimeter. In life it was attached to a specimen of *Lophospira lirata* Ulrich, which probably is identical with the species described by James as *Murchisonia ohioensis*. The upper valve of this *Crania carinata,* the only valve known, reproduces in a remarkable manner even the minute striations of that part of the *Lophospira* upon which it grew. The specimen rested directly upon the trilineate slit-band and extends from this band upward sufficiently to include the carina on the upper slope of the whorl, and downward beyond an apparently nearly obsolete carina on the lower slope. The markings on the *Crania* indicate that the slit-band had a width of 0.7 mm., transverse striæ approach this slit-band both from the upper and lower slopes of the whorl so as to curve

strongly backward in the immediate vicinity of the band, in crossing this band the striæ present a concave curvature toward the peripheral notch, and the median striation of the slit-band is almost as sharply defined as the limiting striations of this band. All of these are features in exact accordance with typical *Lophospira lirata,* or at least its variety *obsoleta.*

In searching for the features which are characteristic of the species *Crania percarinata* it is necessary to ignore those striations which evidently are merely reproductions of the surface characteristics of the *Lophospira* upon which the *Crania* rested. In searching for these features it is noted that the shell is marked by the concentric striations found in practically all Cranias. It is a part of one of these concentric striations, in addition to a small deformation due to compression, which is incorrectly figured by Hall and Clarke on the right side of their figure, which is so oriented as to place the peripheral notch on the right. Gasteropoda, however, are more commonly placed with the apex at the top, which would cause the peripheral notch to open toward the left side of the whorl. In addition to the concentric striæ there are traces, along one margin, of very minute granules arranged more or less in radiating lines. The latter are regarded as characteristic of one Eden species, of which *Crania percarinata* apparently is the first described specimen.

The specimen represented by figure 31, in the Hall and Clarke publication, evidently rested upon a *Conularia,* somewhere near its apex, where the width of one of the four faces could not have exceeded 3 mm. The surface of the *Crania* reproduces in minute detail the surface features of the *Conularia*: the longitudinal groove at one angle of the Conularia, the slightly concave depression along one of the sides of the *Conularia,* the sharply defined transverse striations rising in the form of a very broad inverted V if the specimen be held with the larger end of the *Conularia* toward the top. Of these transverse striations there are about 18 in a length of 3 mm. The short striations within the grooves between these transverse striations are at right angles to the latter and may be detected readily along one part of the *Crania.* The figure presented by Hall and Clarke is so oriented that if the supporting *Conularia* were present, the pointed apex of the latter would be directed toward the right of the figure, and the vertical groove along the angle should be along the lower third of the figure.

Ignoring these surface features, which are merely a reproduction of those belonging to the supporting *Conularia,* a few concentric markings may be seen along the margin of the *Crania,* but no minute granulations arranged along radiating lines.

28. **Crania parallela,** Ulrich

(*Plate VI, Figs. 2, 3*)

1878. Crania parallela Ulrich, Jour. Cincinnati Soc. Nat. Hist., 1, p. 98, Plate 4, Fig. 13

The types of *Crania parallela,* including the specimen figured in the original publication, belong to the collection of Prof. Charles Schuchert, of Yale University, and were found in the Economy member of the Eden group, about 100 feet above low water in the Ohio river, at Covington, Kentucky.

In the figured specimen, (fig. 13 of original publication; fig. 2 on plate VI of present bulletin) one side of the shell has been broken off but originally it must have been about 8 mm. in width. About 16 nearly straight ridges cross the shell vertically. Of these ridges there are 14 in a length of 5 millimeters. In the narrow grooves between these ridges there are indications of numerous short striæ perpendicular to the ridges, suggesting that the *Crania* was attached to a *Conularia.* Aside from these features, which evidently do not constitute a specific characteristic of the *Crania,* there are numerous very minute granules scattered quite irregularly over the surface, with only a faint tendency toward radial arrangement. These granules are regarded as characteristic of an Eden species which has been described under several names based on surface features shown by individual specimens, and which vary with the character of the supporting surface.

A second specimen, B, 6 mm. in width, was attached to one of the faces of a *Conularia.* There are 12 transverse ridges in a length of 3 mm. These ridges meet at an angle of 130° at the middle of the face of the *Conularia.* The short vertical ridges in the grooves between these ridges are very plainly shown. Minute granules characteristic of the *Crania* rather than of the *Conularia* apparently may be detected.

A third specimen, C, (figure 3 on plate 6, in this bulletin), 6 mm. in width, is crossed at irregular intervals by moderately

diverging striations, which evidently reproduce the markings on the surface of the shell upon which the *Crania* rested. In addition to these striations, this specimen is marked by numerous very minute granules which are arranged in an irregular manner but are elongated in a radial direction, locally producing the appearance of scattered, very short radial striæ. In no other specimens are these minute granules better defined, and hence this specimen C may be regarded as most typical of those lower Eden forms of *Crania* which are characterized by the presence of minute granules. These forms, probably constituting a single Eden species, have been described under various names suggested by surface features conditioned by the supporting surface.

In a fourth specimen, D, 5 mm. in width, sharp, transverse striations with finer intermediate striæ occur at irregular intervals, but there are no traces of granules.

In a fifth specimen, E, 9 mm. in width, the transverse striations are sufficiently broad to suggest that the *Crania* rested upon a *Byssonychia.* Eight of these striations, or rather plications, occupy a width of 4 millimeters. There are also concentric markings but no trace of granules. In another *Crania* upon the same rock fragment, but without transverse striations, very minute fibrous lines, much more minute than the granules and radiating lines mentioned in the description of any of the other Cranias from the lower Eden, radiate from the strongly excentric apex toward the circumference of the nearly circular shell. The latter is 4.3 mm. in width. In addition to this, the inner side of one of the valves of this *Crania,* 4.5 mm. in diameter, is exposed.

In a sixth specimen, F, about 4 mm. in width, there is the same irregular alternation of coarser and finer sharp striæ as in specimen D, suggesting that the supporting shell may have been a gasteropod, but there are no indications of minute granules. Another specimen on the same rock fragment does not present any cross-striations, due to support on a striated shell. As in the case of the nearly circular *Crania* associated with specimen E, the apex is very excentric, there are numerous fine concentric striæ, and a few traces of exceedingly minute fibrous radiate structure of an indefinite character. The length of this specimen is 5 mm., the width is 5.8 mm., and, in the present flattened condition of the shell, the apex is about 1.7 mm. from the posterior margin.

29. **Crania socialis,** Ulrich

(*Plate VI, Fig. 4; Plate III, Figs. 11 A, B*)

1878. Crania socialis Ulrich, Jour. Cincinnati Soc. Nat. Hist., 1, p. 98, Plate 4, Fig. 14

1892. Crania socialis Hall and Clarke, Pal. New York, 8, pt. 1 Plate 4 H, Fig. 29

The types of *Crania socialis,* including in addition to the specimens figured by Ulrich and by Hall and Clarke in the publications cited above, also several additional specimens, belong to the collection of Prof. Charles Schuchert, of Yale University, and were found at different elevations in the Eden group at Cincinnati, Ohio.

The type figured by Ulrich (fig. 4 on plate 6 of present bulletin), is a free upper valve resting upon a rock fragment containing *Cryptolithus tessellatus* (*Trinucleus concentricus*), and probably was found in the lower half of the Eden group. It is 2 mm. in length, 4.5 mm. in width, and has a convexity of about two-thirds of a millimeter. It is crossed by 7 vertical ridges, evidently representing the same number of columnals on that part of the crinoid stem to to which it was attached. There are faint traces of minute concentric striæ but no evidences of granules or radiating striæ.

The specimen figured by Hall and Clarke consists of a circular crinoid stem about 12 mm. in length and 3.3 mm. in diameter, with 14 columnals, alternating in size, in a length of 10 mm. Both the larger and smaller columnals are repeated in the broad ridges crossing the Cranias. Of the latter, there are 10 attached to the crinoid stem fragment. The longest diameter of the Cranias is parallel to the length of the crinoid stem. There is no clear evidence of minute radiating striæ.

In a third specimen, C, there are 10 Cranias attached to a crinoid stem fragment 17 mm. in length; of these 6 are quite conspicuous, and on one of them radiating striæ diverge very distinctly from an apex situated near one end of the longest diameter of the specimen. On one of the other shells these markings appear more like granules strongly elongated in a radial direction; in this shell the apex is situated along the shorter diameter.

Traces of radiately elongated granules are seen also on Cranias attached to specimens D, and E.

One of the most elongated shells occurs on Specimen F. In this shell the length is 7.5 mm., the transverse diameter is 2.2 mm. and the apex at present rises fully 2 mm. above the curvature of

the crinoid stem, but this evidently is due in part to compression parallel to the shorter axis of the shell. Only very obscure traces of elongated granules are noticed at one point along the margin of the shell.

Another specimen of *Crania socialis* is numbered 8868 in the Faber collection at Chicago University. It consists of 17 larger and 10 considerably smaller shells attached to a crinoid stem 22 mm. long and 3.5 mm. in diameter. At first sight this group of shells appears merely like numerous specimens of *Crania scabiosa.* Their surfaces are comparatively smooth, and there are traces of concentric striæ, although these are not very conspicuous. On closer examination, however, very fine radiating lines are noticed, which apparently consist of irregularly arranged short striæ directed in a radiating direction. These striæ are preserved best along the younger parts of the shells, along the margin, the older, more central parts, being smooth.

30. **Crania albersi,** Miller and Faber

(Plate III, Figs 8 A, B)

1894. Crania albersi, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 154, Plate 8, Figs. 17-19

The type of *Crania albersi,* No. 8863 in the Faber collection at Chicago University, consists of an upper valve resting upon a specimen of *Zygospira modesta.* The *Crania* evidently was not attached to the *Zygospira* during life, but the upper valve of the *Crania* had become loosened from its original area of attachment and had drifted to its present position, on top of the *Zygospira,* before becoming buried in the sea mud. Its original support must have been some shell with much narrower and less divergent markings than the plications of *Zygospira modesta,* judging from the narrow, subparallel plications, approximately vertical to the posterior margin, which are shown by the type, and which evidently are superimposed upon the fine radiating striæ characteristic of the species of *Crania* under discussion. The supporting shell may have been some species of *Rafinesquina.* The length of the type specimen is 4 mm.; the width can not be determined with accuracy since the margin on the right side of the specimen is broken away for its entire length, but this width is estimated at 5.3 mm., and the height of the valve is about 1.5 mm. Along the margin of this type, the number of radiating striæ varies from 6 to 8 in a width

of one millimeter. *Crania albersi* was described from the Economy member of the Eden group at Cincinnati, Ohio. The fragment of rock supporting the *Crania* contains also traces of *Cryptolithus tessellatus* Green.

Compared with *Crania laelia* Hall, from the Maysville and Richmond groups of Ohio and Indiana, *Crania albersi* is less rotund, has a more definite and straighter posterior margin, the apex is nearer this posterior margin, and the radiating striæ are finer.

31. **Whitella cuneiformis,** Miller

(Plate VII, Figs. 1 A, B, C)

1881. Orthodesma cuneiforme Miller, Jour. Cincinnati Soc. Nat. Hist., 3, p. 314, Plate 8, Figs. 1, 1a

1889. Sphenolium cuneiforme Miller, genotype, N. A. Pal., p. 513

The type of *Orthodesma cuneiforme* is numbered 8803 in the Faber collection at Chicago University. It is labelled as coming from Versailles, in Indiana, and probably came from the Waynesville member of the Richmond formation. It evidently belongs to the group of shells typified by *Whitella sterlingensis* Meek and Worthen, for which Meek proposed the generic term *Rhynchotropis,* without describing this genus, however. *Whitella sterlingensis* is a typical fossil of the Maquoketa member of the Richmond, in Illinois and Minnesota. *Whitella hindi* Billings, from the Lorraine on the Humber river, at Toronto, in Ontario, belongs to the same group.

This group of shells is characterized chiefly by the great elongation of the shell in a direction parallel to the umbonal ridge, the latter being strongly oblique to the hinge-line. The hinge-line extends only a moderate distance anterior to the beak, and the extension posterior to the beak is much shorter than the distance from the beak to the posterior termination of the shell along the umbonal ridge. Ventrally, the umbonal ridge rounds gradually into the general curvature of the shell as far as the ventral margin, but dorsally the shell is strongly compressed, especially anteriorly, toward the beaks, so as to produce a flattened appearance when examined from above. Posterior to the beaks, there is a well defined escutcheon.

The type of *Orthodesma cuneiforme* is an internal cast. Its length from the beaks to the posterior margin, along the umbonal ridge, is 80 mm.; its thickness from valve to valve is 3.6 mm. The distance along the hinge-line from the tips of the beak to the posterior end of the hinge-line is estimated at 30 mm.; anterior to the beak the hinge-line extends between 5 and 7 mm. With this hinge-line the umbonal ridge forms an angle of about 50 degrees. The type is defective along the basal margin and along the entire posterior margin, but enough is preserved to indicate the general outline.

In a second specimen of Whitella cuneiforme, presented to me by Prof. W. H. Shideler, of Miami University, obtained somewhere in the lower part of the Richmond in Warren county, Ohio, the basal margin is well preserved, and more is preserved of the parts bordering on the posterior margin. This shell differs from the type only in having the umbonal ridge more inflated anteriorly, so that a moderately concave curvature exists between the anterior half of the umbonal ridge and the anterior half of the basal margin of the shell.

The specimen figured by Miller and Faber as *Sphenolium cuneiforme* (Jour. Cincinnati Soc. Nat. Hist., 17, 1894, p. 141, pl. 8, figs. 5, 6), from the same locality as the type of that species, was incorrectly identified. It forms No. 8792 in the Faber collection at Chicago University, is labelled as coming from Versailles, in Indiana, and evidently is a species of *Modiolopsis*. The specimen is badly crushed along the umbonal ridge posteriorly, and all of the upper part, posterior to the beak, is missing. The shell, originally, was only moderately convex, the mesial depression anterior to the umbonal ridge was weakly defined, there was no concave curvature along the base, and if *Modiolopsis versaillesensis* ever attained so large a size, these incorrectly identified specimens probably belonged to that species.

32. **Whitella richmondensis,** Miller

(Plate VII, Figs 2 A, B, C)

1889. Sphenolium richmondense Miller, N. A. Geol. Pal., p. 513, Figs. 925, 926

The type of *Sphenolium richmondense* is numbered 8800 in the Faber collection at Chicago University. It is labelled as coming

from Richmond, in Indiana, and is assumed to have been obtained in the Whitewater member of the Richmond group. The specimen is altogether too poor to merit its use as a type of a new species. The small anterior extension of the shell, the prominent umbonal ridges, the rhombic-cordate outline of the shell when viewed from the front, the steep post-umbonal slopes of the shell extending from the umbonal ridge to the dorsal margin, and the extreme thinness of the shell, as far as may be determined from the parts preserved, all suggest the affinity of this type specimen with some species of *Whitella.*

Compared with *Whitella cuneiformis,* the posterior slope of the umbonal ridge is distinctly less flattened, and the curvature between the umbonal ridge and the dorsal margin is distinctly more concave; moreover, the shell does not appear to have been so strongly elongated. The absence of strong flattening along the posterior slope of the umbonal ridges distinguishes this type also from *Whitella hindi* Billings and *Whitella sterlingensis* Meek and Worthen. The general outline, as far as may be judged from the imperfect specimen at hand, was much more oblique than in *Whitella quadrangularis* Whitfield or *Whitella subovata* Ulrich. Compared with *Whitella umbonata* Ulrich, the umbones are far less prominent. Compared with *Whitella obliquata* Ulrich, the umbones appear more gibbous and the outline of the shell is more broadly cordate when viewed from the front. From both *Whitella obliquata* and *Whitella ohioensis* Ulrich it differs in being narrower anteriorly, the anterior part of the basal margin being less convex and more nearly parallel to the umbonal ridge. In other words, *Whitella richmondensis* does not appear to be identical with any of the species of *Whitella* described from the Cincinnatian beds of Ohio or Indiana. This, however, might easily be explained by the fact that all of the latter have been described from the Waynesville member of the Richmond, while *Whitella richmondensis* probably was obtained from the Whitewater member, and may be a distinct species. It must be acknowledged, however, that the type does not give much definite information as to the characteristics of this species. The most disconcerting fact about the type is the presence of a distinct elevation along that part of the hingeline, posterior to the beaks, where the escutcheon ought to be. I have assumed that this elevation is, in part at least, a remnant of the matrix, and that well preserved specimens, exposing this part of the shell, would show an escutcheon.

33. **Cyrtodonta cuneata,** Miller

(*Plate VII, Figs 3 A, B, C, D*)

1878. Angellum cuneatum Miller, Jour. Cincinnati Soc. Nat. Hist., 1, p. 106, Plate 3, Fig. 11

1908. Cyrtodonta cuneata Cumings, 32d Ann. Rep. Dep. Geol. Nat. Res. Indiana, p. 999, Plate 45, Fig. 2

The type of *Angellum cuneatum* is numbered 8815 in the Faber collection at Chicago University. It is labelled as coming from Richmond, Indiana, and lithologically appears as though it had come from the Whitewater member of the Richmond. The specimen has been so strongly carved by some one who desired to clean the specimen, that its present form is more manufacutred than natural. This is true especially of the part immediately anterior to the beak and of that part of the anterior margin where a cast of an anterior muscular scar has been carved out in a very unnatural location, far below the position which it must have occupied.

The type evidently is a cast of the interior. The beaks appear to have been small and narrow. An angular ridge extends ventrally from the beak, in this cast, but disappears at a point slightly more than half way from the beak to the ventral margin. Anterior to the beak, a small but deep lunule has been carved out, and posterior to the beak a high hinge area is seen. It is evident that the greater part of the posterior portion of the shell is absent, but traces of concentric striæ suggest that the shell was comparatively short.

There is a possibility of *Angellum cuneatum* being related to *Bodmania insuetum*, a species also described from the Whitewater at Richmond, Indiana, (1894, Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 23, pl. 1, figs. 5-7), apparently another Cyrtodontoid form, but the latter appears to have had more prominent and inflated beaks, giving it a much more broadly rhombic-cordate outline when viewed from the front. The attempted restoration of the posterior parts of this type, as shown by figure 3C on plate VII, may be regarded as a wild guess. D

34. **Anomalodonta alata,** Meek

(*Plate IV, Fig. 2*)

1872. Ambonychia alata Meek, Proc. Acad. Nat. Sci. Philadelphia, p. 319

1873. Ambonychia alata Meek, Geol. Surv. Ohio, Pal. 1, p. 131, Pl. 11, Fig. 9, Plate 12, Fig. 10

Both of the types figured by Meek in the Paleontology of Ohio, cited above, are numbered 2341 in the James collection at Chicago

University. Both of these types are impressions of the exterior of right valves, preserved in limestone. The original of figure 9 on plate 11 occurs in limestone containing numerous fragments of *Rafinesquina alternata* but only one fragment of *Dalmanella jugosa;* a single squarish columnal, possibly belonging to *Compsocrinus,* also is present. Twenty-four radiating plications are indicated plainly but the margin of the byssal opening is not preserved, so that there may have been one or two additional plications in this region. The original of figure 10 on plate 12 appears to have come from the same rock layer as the original of the specimen just described. Twenty-eight radiating plications can be recognized readily and in addition to these there were probably one or two more in the region of the byssal opening. Both of these types probably were derived from the Waynesville member of the Richmond group, at Clarksville, in Clinton county, Ohio.

A third specimen, also numbered 2341, but evidently not at hand at the time the figures of the types were prepared, since it is a much better specimen than the other two and presents a well preserved and nearly entire left valve, is included in rock containing *Dalmanella jugosa,* several square columnals suggesting *Compsocrinus,* and various minute ostracods. The specimen is especially interesting in presenting an excellent example of the margins of the different stages of growth (in this case, four stages) remaining free from the main body of the shell, producing more or less squamose concentric bands.

The specimen figured in this bulletin was obtained by the writer on Clifty Fork, west of Madison, Indiana, a considerable distance below the lowest horizon in the Waynesville member of the Richmond group at which *Dalmanella jugosa* is found. The thickness of this shell from valve to valve is 27 millimeters. Twenty-four radiating plications are exposed and the original number may have equalled twenty-eight.

The distinguishing features of *Anomalodonta alata* are the rather concave anterior outline, the moderately sinuous posterior outline with the moderate prolongation of the shell along the hinge-line, and the relatively moderate width of the interspaces between the radiating plications, which may equal the latter but frequently are somewhat narrower. Toward the antero-ventral margin of the shell, the plications curve moderately forward. Most of the plications originate at the beak, but along the hinge-line and on the

anterior slopes of the shell there frequently is evidence of the intercalation of one or two additional plications.

35. **Anomalodonta costata,** Meek

(*Plate IV, Fig. 3*)

1873. Ambonychia costata Meek, Geol. Surv. Ohio, Pal., 1, p. 130, Plate 12, Figs. 5, a, b, c

The type of *Anomalodonta costata* is numbered 790 in the James collection at Chicago University. It posseses 19 simple radiating plications but the original number may have equalled 24. Compared with *Anomalodonta alata,* the radiating plications are distinctly narrower and are separated by relatively broader interspaces, which on account of their considerable width appear comparatively flat. *Anomalodonta costata* is a smaller species, usually not exceeding 50 mm. in height. The concave curvature of the anterior margin and the sinuous curvature of the posterior margin are both less, and the latter can scarcely be said to be alate; both of these features are possessed also by *Anomalodonta alata* during its younger stages. The posterior margin of *Anomalodonta costata* rarely is well preserved but its direction is indicated frequently by the direction of the concentric striæ upon such parts of the shell as remain. The type is labelled as coming from Cincinnati, Ohio, but the horizon of the species is known to extend from the Arnheim, where frequently it is common, into the Waynesville member of the Richmond. As in the case of *Anomalodonta alata,* one or two additional plications are intercalated occasionally along the hinge-line or on the anterior slope of the shell. The total number of plications may reach 27 or 28.

36. **Byssonychia robusta,** Miller

(*Plate IV, Figs 1, A, B, C*)

1881. Ambonychia robusta Miller, Jour. Cincinnati Soc. Nat. Hist., 3, p. 315, Plate 8, Figs. 3, 3a

1893. Byssonychia richmondensis Ulrich, Geol. Surv. Ohio, 7, p. 632, Plate 45, Figs. 3, 4

The types of *Byssonychia robusta* are numbered 8816 in the Faber collection at Chicago University. They are described as coming from near Osgood, in Indiana, but are labelled as coming from Versailles, Indiana. At both localities, and at numerous in-

termediate points, *Byssonychia robusta* occurs associated with *Dystactospongia madisonensis* at the base of the massive *Tetradium* layer at the base of the Saluda member of the Richmond group. The original of the type represented by figure 3, accompanying the original description, is used for figures 1A, 1B in the present bulletin. The original of figure 3a accompanying the original description is represented in this bulletin by figure 1C. The latter specimen is unquestionably a typical example of the species described later by Ulrich as *Byssonychia richmondensis*, and is evidently the type which Miller had in mind when he described the species as having its "anterior side flattened and depressed in the region of the byssus; beaks acute, triangular," and refers to the "abrupt bending over of the shell on its anterior side."

Formerly I thought that the original of the figure 3, presented by Miller, might represent a relatively broader species, distinct from *Byssonychia richmondensis*. Later, however, I had the opportunity of seeing hundreds of specimens of *Byssonychia robusta* at its type horizon, where it often is very abundant, and it soon became evident that the broader specimens, as represented by the specimen used for figure 3, by Miller, were the normal forms, while the more elongate forms, suggesting *Byssonychia richmondensis*, as figured by Ulrich, showed indications of compression anteroposteriorly. This compression not only gave a more elongate appearance to the shell, but made the angular bending of the shell along the umbonal ridge more abrupt, and made both the plications and the interspaces between these plications more narrow, although of course, not changing their number. From this it must not be assumed that the broader form, used by Miller for figure 3, does not show any abrupt bending over of the shell anteriorly. This abrupt bending is confined usually to the upper half of the shell. Along the lower half, the umbonal ridge is merely strongly rounded. The very angular, almost acutely angular bending of the shell is confined to those parts within 20 mm. of the beak, and from this distance downward the angularity of the umbonal ridge gives way gradually to more and more pronounced rounding. In this respect the original of figure 3, as published by Miller, was as typical as the original of his figure 3a, but in the former specimen the shell is not preserved along the angle of the umbonal ridge near the beak, but comparison with numerous other specimens from which the shell substance has been removed indicates that the cast of the interior

of this valve along the upper part of its umbonal ridge is perfectly normal for the species, as typified by numerous specimens, entirely uncompressed, found at the type horizon.

In more recent years I have found specimens of *Byssonychia richmondensis* as far off as Manitoulin island, and there also have noted the evidence of moderate antero-lateral compression resulting in a more elongate appearance of the shell, and in a greater angularity along the umbonal ridge.

If *Byssonychia richmondensis* of Ulrich represents a form distinct from those which I have identified as equivalent to his species, then I have never seen his species.

In *Byssonychia robusta* there are about 30 to 33 radiating plications posterior to the sharpest part of the umbonal ridge, and 8 or 9 additional ones between this part of the umbonal ridge and the base of the byssal opening. The species occurs both in the Saluda and in the Whitewater members of the Richmond, the former being regarded as chiefly a southern more arenaceous, less fossiliferous phase of the greater part of the Whitewater and of a small part of the Elkhorn member of the Richmond group, as exposed farther north in Indiana.

37. **Cymatonota cylindrica,** Miller and Faber

(*Plate VI, Figs. 7 A, B*)

1894. Orthodesma cylindricum Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 22, Plate 1, Figs. 1-4

The types of *Orthodesma cylindricum* are numbered 8801 in the Faber collection at Chicago University. They are described as coming from above the middle of the Cincinnatian series of rocks in Warren county, Ohio, but are labelled as coming from Cincinnati, Ohio. Of the specimens figured by Miller and Faber, the one used for figure 1 is missing. The specimen used for figures 2 and 3 is fairly well preserved, and is illustrated in the present bulletin. The original of figure 4 is considerably distorted but shows the characteristic wrinkles along the hinge-line and the concentric striæ of the general surface of the shell very well. The type evidently is identical specifically with *Cymatonota typicalis* described by Ulrich from the Waynesville member of the Richmond group at Waynesville, Ohio. Miller and Faber's description was published in 1894, while Ulrich's description, was published, in volume 7 of the Geology of

Ohio, in 1893, so that the term *Cymatonota typicalis* has precedence.

The specimen figured in this bulletin is 66 mm. long, 15 mm. high at the beak, 18 mm. high at the rear, and 11.5 mm. thick from valve to valve. The thickest part is near mid-length, or a short distance posterior to mid-length, and from this point the shell tapers gradually in both directions, gaping at the ends. Only the stronger concentric markings are preserved, the finer striations being absent. Oblique wrinkles border the hinge-line for a distance of 25 mm. posterior to the beak. The beaks are strongly flattened and approach each other closely. Along the area marked by oblique wrinkles, the umbonal ridge diverges but moderately from the level of the hinge-line, and then curves more rapidly toward the lower posterior angle. The very shallow mesial depression extends for almost the entire length of the shell, producing a slight concave curvature along the basal margin of the shell. The anterior end of the shell is almost evenly rounded and extends about 13 mm. anterior to the beak.

38. **Modiolopsis versaillesensis,** Miller

(*Plate IV, Fig. 4*)

1874. Modiolopsis versaillesensis Miller, Cincinnati Quart. Jour. Sci., 1, p. 150, Figs. 13, 19

1894. Modiolopsis versaillesensis, Ulrich, Geol. Minnesota, 3, pt. 2, p. 521, Fig. 40a

Three left valves, numbered 8791 in the Faber collection at Chicago University, are labelled as *Modiolopsis versaillesensis* and as coming from Versailles, Indiana. Of these, the largest specimen is regarded as the original of figure 18 accompanying the original description, and another figure of the same specimen is presented in the present bulletin. All three specimens evidently came from the *Cycloconcha milleri* horizon in the Waynesville member at Versailles, Indiana. Compared with the figure presented by Miller, the beak is less prominent anteriorly; otherwise the agreement is quite close. The type is 45 mm. long, has a maximum height of 25 mm., and the thickness from valve to valve is about 14 or 15 mm. judging from the convexity of the single valve here measured. Concentric striations are well marked along the anterior margin and along the post-umbonal slope near the hinge-line; along the ventral margin of the shell they are only moderately distinct, and toward the umbonal ridge they frequently are faint. The shell is only moderately convex. The umbonal ridge is distinctly but not

strongly indicated. The mesial depression anterior to the umbonal ridge is slight. There practically is no mesial sinus along the ventral margin, the latter being straight along the base of the mesial depression.

39. **Modiolopsis brevantica,** n. sp.

(*Plate V, Figs. 1 A, B*)

Species apparently belonging to the same group as *Modiolopsis concentrica*, but much more convex. Anterior margin sloping obliquely downward, and projecting only 3 millimeters anterior to the beak. Posterior part of the cardinal margin only slightly convex for a distance of 15 millimeters from the anterior part of the beak, and then deflected downward at an angle of about 140 degrees. The umbonal ridge has about the same direction, 140 degrees with the horizontal. The shell is swollen out along the umbonal ridge, the greatest distance from valve to valve equalling 12 millimeters, at a distance of 12 millimeters from the beak. The shell is vertically compressed along the base, but it is evident from the concentric lines ornamenting the surface that it was long and slender. The base has about the same direction as the umbonal ridge, and therefore also forms an angle of about 140 degrees with the horizontal. The lowest part of the base reaches about 21 millimeters below the horizontal continuation of the hinge-line. The greatest width of the shell between the basal and posterior outlines equals about 16 millimeters. Both anteriorly and posteriorly the shell is quite evenly rounded. The mesial sinus is shallow and not strongly defined. The umbonal ridge is fairly angular anteriorly and is much more strongly defined than in *Modiolopsis concentrica.* The beaks are small and approach each other closely. The preumbonal slopes are flattened. Viewed from above, the shell has an elliptical-lanceolate outline. The surface is quite strongly ridged concentrically, 7 ridges occupying a length of 5 millimeters along the umbonal ridge.

Found in the Waynesville member of the Richmond at Clay cliff, 3 miles north of Wekwemikongsing, on the eastern shore of Manitoulin island, Canada.

40. **Pholadomorpha pholadiformis,** Hall

1851. Modiolopsis pholadiformis Hall, Geol. Lake Superior Land. Dist., Foster and Whitney Rep., p. 213, Plate 30, Figs. 1 a-c; Plate 31, Fig. 1

Pholadomorpha pholadiformis is characterized so strongly by its peculiar surface ornamentation that it seems almost incredible

that it could have been described under three different names by the same individual, Miller. One of these so-called species merely is due to obliquely vertical compression of the shell in the soft shale and in the original Miller collection was represented by numerous specimens differing so widely among each other in the location of the so-called plications or sulcæ that suspicion certainly should have been aroused as to the specific value of these features. A second one of these so-called species represents merely a specimen preserved in soft shale and crushed flat while lying on its side. The third specimen was preserved with a limestone matrix filling its interior, and this specimen retains not only its original shape but part of the shell substance itself. These so-called species were described as *Modiolopsis sulcata, Modiolopsis corrugata,* and *Modiolopsis capax.*

For the fourth term, *Sedgwickia divaricata,* proposed by Hall and Whitfield, there is more excuse. The specimen is a much younger one than those found ordinarily, and the plications are very strongly marked for such a young specimen, presenting a very unfamiliar appearance.

These so-called species are described and figured on the following pages in order to put on record what they really are.

It is probable that the present writer has himself added to this list of synonyms by describing a Canadian specimen, very much like the *Modiolopsis capax* of Miller, as *Pholadomorpha chambliensis.*

41. **Pholadomorpha divaricata,** Hall and Whitefield

(*Plate V, Figs. 3A, B, C*)

1875. Sedgwickia ? divaricata Hall and Whitfield, Geol. Surv. Ohio, Pal., 2, p. 89, Plate 2, Fig. 3

1914. Pholadomorpha pholadiformis divaricata Foerste, Bull. Sci. Lab. Denison Univ., 17, p. 279, Plate 2, Fig. 14

The type of *Sedgwickia divaricata* is preserved in the James collection at Chicago University, and is there numbered 1489. It was described as found in the shales of the Hudson River (Cincinnati) group, at Blanchester, Ohio. The best exposures in the vicinity of Blanchester occur about a mile west of town, along the creek about a quarter of a mile north of the railroad. Here the upper or Blanchester division of the Waynesville member of the Richmond is exposed, but the immediately underlying parts of the middle or

Clarksville division are seen farther westward, along the same stream. From this it is assumed that the type was found in the upper part of the Waynesville. Three figures of the type are given in this Bulletin.

There is no doubt of this type being merely the young of some species of *Pholadomorpha*, presumably *Pholadomorpha pholadiformis*. The figure accompanying the original description is slightly enlarged in the effort to represent the specimen as entire, and the prominence of the beak and of the umbonal ridge is greatly exaggerated. The basal margin is less convex than in this figure, especially posteriorly. The concentric wrinkles are strongly defined in case of the right valve, less strongly in case of the left valve. Along the cardinal margin these concentric wrinkles form angles of about 40 degrees with this margin; here they are fairly well defined if held transversely to the light. The chief difficulty in recognizing those parts of the concentric wrinkles which border on the cardinal margin is the presence of the transverse plications which make their appearance within 8 millimeters of the beak, and become more prominent posteriorly. On this account, only those concentric wrinkles which are near the beak are recognized readily on the postumbonal slopes. The transverse plications on the slope beneath the umbonal ridge are low and broad, but distinctly defined.

There is no reason for believing that *Sedgwickia divaricata* represents a distinct species. It is merely a specimen of *Pholadomorpha pholadiformis* in which both the concentric wrinkles and the transverse plications were strongly defined even at an early stage of growth. This suggests that at mature age this type would have been characterized by strongly marked transverse plications even along the postumbonal slopes, as in the specimen figured as *Pholadomorpha divaricata* from the Richmond of the Rivière des Hurons, in the province of Quebec, in this Bulletin, volume 17, on plate 2. It is not certain, however, that the type of *Sedgwickia divaricata* would have developed into a form with as strongly divergent cardinal and basal margins as the latter specimen.

42. **Pholadomorpha capax,** Miller

(Plate V, Figs. 4A, B)

1889. Modiolopsis capax Miller, N. A. Geol. Pal., pp. 489, 490, Fig. 851

The type of *Modiolopsis capax*, figured in this Bulletin, forms No. 8802 in the Faber collection at Chicago University, and retains

also the number 407 which it had in the Faber collection. It was obtained at Versailles, Indiana, presumably in the Waynesville division of the Richmond. The shell unquestionably belongs to the *Pholadomorpha pholadiformis* group, and, if it differs at all from the latter species, this difference consists chiefly in a smaller deviation between the cardinal and basal margins. However, there is a probability that in a perfect condition of the shell the cardinal margin would be straighter for a longer distance posteriorly, and that the basal margin would deviate more from the cardinal margin. Accepting this interpretation, the type of *Modiolopsis capax* is less interesting as a possible new species than as an excellent representative of an old one.

Most specimens of *Pholadomorpha pholadiformis* preserve the valves in a more or less compressed condition, owing to their preservation chiefly in clay shales or in very argillaceous limestones. The type of *Pholadomorpha capax*, however, is preserved in a fine grained limestone, and, apparently, retains its original convexity very well, as far as it is preserved at all. From this the following description is drawn.

The greatest thickness of the shell, or distance between the valves, occurs at mid-length, along the umbonal ridges. From this point the shell tapers both anteriorly and posteriorly. The thickest part of the shell is about 20 millimeters posterior to the beak, where it equals 20 millimeters. At the beaks, the thickness is reduced to about 14 millimeters. Forty millimeters posterior to the beak, the thickness still equals 19 millimeters, but posterior to the latter point the reduction in thickness is more rapid.

The umbones are strongly compressed and flattened, the flattening affecting practically all of the shell anterior so the umbonal ridge. Basal margin straight, mesial sulcus practically obsolete. Umbonal ridge rounded, only moderately distinct for a distance of 20 millimeters posterior to the beak along which the cardinal surface of the shell is more or less flattened horizontally. Posteriorly, the umbonal ridge becomes almost obsolete, being indicated by a slight flattening of the postumbonal slope. Posterior outline probably as in other specimens of *Pholadomorpha pholadiformis*.

A part of the original shell substance is preserved. The thickest part of the right valve is found in the area extending from the cardinal margin downward for a distance of 10 millimeters from a point 10 millimeters anterior to the beak, where the thickness is

about three-fourths of a millimeter, to a point 15 millimeters behind the beak, where the thickness equals about half a millimeter, excepting along the immediate vicinity of the hinge-line. Toward the basal margin, the thickness of the valve diminishes to scarcely more than a sixth or a seventh of a millimeter.

The shell is distinctly wrinkled concentrically, the wrinkles being quite strong anteriorly, from the umbonal area as far down as the basal margin, although not quite as distinct as in the umbonal region of *Sedgwickia divaricata* Hall and Whitfield.

Transverse, low, rounded plications, distinctly defined anteriorly, where the shell is preserved; less distinctly defined posteriorly, along the hinge-line, where the shell is partly exfoliated; almost invisible along the lower, posterior part of the internal cast of the right valve, where all of the shell substance is gone.

Faint, broad grooves radiate from the posterior side of the beaks along the post-umbonal slope, but are thought to have no special significance. Similar grooves are seen occasionally in *Modiolopsis.*

Additional information regarding the shell substance of *Pholadormorpha pholadiformis* is presented by a specimen collected by the writer in a limestone layer at the top of the Waynesville member of the Richmond, along Cowan creek, southeast of Clarksville, Ohio. The outer black coat of the shell is very thin, as thin as paper. This is the part which is preserved in the form of a thin black film in the fine-grained sandstones of the so-called Lorraine of New York, Canada, and Wisconsin. The remainder of the shell is much thicker, especially toward the umbonal region, where it reaches a thickness of about two-thirds of a millimeter. This part of the shell consists of vertical fibers, possible of aragonite, and this is the part which usually is not preserved, especially in argillaceous and arenaceous strata. Anteriorly, the concentric wrinkles are well marked. Posterior to the beak, both along the base and along the hinge-line, the transverse plications are well defined, extending toward the crest of the umbonal ridge.

43. **Pholadomorpha corrugata,** Miller and Faber

(Plate V, Fig 5)

1892. Modiolopsis corrugata Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 15, p. 79, Plate 1, Fig. 1

The type of *Modiolopsis corrugata* forms No. 8813 in the Faber collection at Chicago University. It was described as coming from

near the top of the hills, in Cincinnati, but the museum label bears the legend, "Warren Co., Ohio;" and the latter probably is the real origin. I know of no reason for regarding this type as of earlier age than the Waynesville member of the Richmond.

The type so evidently is merely a flattened specimen of *Pholadomorpha pholadiformis,* such as are characteristic of the soft clay shale deposits in the lower part of the Waynesville member of the Richmond, that it deserves no further comment. The figure presented by Miller and Faber is sufficiently accurate, but another figure is offered in the present Bulletin. The so-called posterior wing, mentioned in the original description, is merely the postumbonal slope. The low, broad, transverse plications along the posterior part of the cardinal margin are sufficiently distinct to suggest those of *Pholadomorpha divaricata,* as figured from the Rivere des Hurons in this Bulletin, in 1914.

44. **Pholadomorpha sulcata,** Miller and Faber

(Plate V, Fig. 2)

1892. Modiolopsis sulcata Miller and Faber, Jour. Cincinnati Soc. Nat. Hist.' 15, p. 79, Plate 1, Fig. 4

The type of *Modiolopsis sulcata,* numbered 8798, is preserved in the Faber collection at Chicago University. It was described as having been found on the hills at Cincinnati, Ohio; on the label, however, the words "Warren Co., Ohio" appear and the latter locality probably was the real origin. I know of no reason for regarding its horizon as having been below that of the Waynesville member of the Richmond.

It is so evident that the type is merely a vertically compressed specimen of *Pholadomorpha pholadiformis* that it is difficult to understand how the specimen came to be described at all. While the vertical diameter of the specimen has been diminished very much by compression, the cardinal view has not been altered greatly, so that from this point of view the flattened umbones, narrowly compressed, and the flattened cardinal slopes immediately posterior to the beaks are well exposed. The lanceolate widening of the shell toward midlength is well preserved. The radiating low broad grooves on the postumbonal slope, mentioned in the case of the interior cast of *Modiolopsis capax,* have been accentuated by the vertical compression, but the figure accompanying the original

description of *Modiolopsis sulcata* is greatly overdrawn. Not only the low transverse plications along the basal margin but also those along the posterior part of the cardinal margin can be detected.

Judging from other specimens of *Pholadomorpha pholadiformis*, one of the faint, broad, radiating grooves of the postumbonal area usually is located immediately above the crest of the umbonal ridge, and a second groove is found a short distance above the first. Additional grooves may occur nearer the hinge-line.

45. **Rhytimya cymbula,** Miller and Faber

(Plate VI, Figs. 8 A, B)

1894. Orthodesma cymbula Miller and Faber, Jour. Cincinnati Soc. Nat. Hist., 17, p. 143, Plate 8, Figs. 7-9

The type of *Orthodesma cymbula* is numbered 8814 in the Faber collection at Chicago University. It was described as not very uncommon in the upper part of the Cincinnati series of rocks in Warren county, Ohio, but the type is labelled as coming from Cincinnati, Ohio. This type, undoubtedly, is identical specifically with *Rhytimya mickleboroughi* Whitfield, as figured by Ulrich in the Geology of Ohio, volume 7, from the Fairmount member of the Maysville group, a fact already indicated by Bassler in his Bibliographic Index of American Ordovician and Silurian Fossils.

The shell substance is very thin. Owing to the prominent umbonal ridges and the flattened dorsal slopes, the cross-section of the shell is strongly triangular. The dorsal flattening is conspicuous for a distance of about 35 mm. from the beaks, and the umbonal ridge makes an angle of about 15 degrees with the hinge-line. A distinct mesial depression extends from the beaks toward the middle of the ventral margin, broadening toward the latter, and forming a concave outline along the latter. Anterior to this depression the shell is swollen along a line forming an angle of about 70 degrees with the hinge-line. Between this part of the shell and the umbonal ridge there are obscure traces of radiating striations. The anterior part of the shell is almost acutely pointed. The upper posterior part of the shell, and the tip of the anterior part are not preserved. The characteristic wrinkles of *Rhytimya* are strongly developed anteriorly, are much less conspicuous within the area of the broad mesial depression, and are weakly defined on the post-umbonal slopes.

46. **Vallatotheca manitoulini,** Foerste

(Plate V, Fig. 6)

1914. Vallatotheca manitoulini Foerste, Bull. Sci. Lab. Denison Univ., p. 482, Plate 4, Figs. 4 A, B)

The type, No. 8448 in the Victoria Memorial Museum, at Ottawa, Canada, was found in the Waynesville member of the Richmond at the Clay Cliff, about four miles south of the termination of Cape Smith, on the eastern shore of Manitoulin island, in Canada. In the present Bulletin, a figure, enlarged about three and a half diameters, is introduced in order to show the radiating striæ and the lamellose lines of growth of the shell. At each of these so-called lines of growth a single lamella curves upward and outward sufficiently to become free from the general surface of the shell for a short distance. The radiating striæ are not strictly continuous from one lamella to the next, each lamella representing a more or less distinct growth of the margin of the shell.

47. **Endoceras arcuatum,** J. F. James

1886. Colpoceras arcuatum, James, Jour. Cincinnati Soc. Nat. Hist., 8, p. 242, Plate 4, Figs. 1, 1a

The type of *Colpoceras arcuatum* should be present in the Museum of the Cincinnati Society of Natural History, but has been lost. According to the author of the species, specimens of the same species should occur in the U. P. James collection. Two specimens, labelled *Colpoceras arcuatum,* and found at Cincinnati, Ohio, are numbered 657 in the James collection at Chicago University. Of these only one shows the degree of tapering demanded by the figure of the type illustrated by James. This specimen is 125 mm. long, 32 mm. wide at the larger end, and 20 mm. wide at the smaller end. The specimen consists of a nearly smooth siphuncle, crossed by faint oblique markings indicating the lines of contact with the septa. Six cameras in a length of 58 mm. were present near the middle of the specimen, and possibly 12 cameras may formerly have been present in its entire length. Parasitic bryozoans are attached to the exterior of this siphuncle and it probably came from the lower part of the Maysville group at Cincinnati, Ohio.

The second specimen, bearing the same number, figure 10 on plate VI of this bulletin, tapers considerably less than the type and is regarded as belonging to a different species of *Endoceras.*

It is 60 mm. long, nearly cylindrical in form, 24 mm. wide, and has 5 cameras in a length of 40 mm. The oblique annulations, indicating lines of contact with the septa, form angles of 70 degrees with the longitudinal axis of the specimen.

A third specimen, numbered 401 in the James collection, found at Harman station in Indiana, and also labelled *Colpoceras arcuatum,* also differs from the type in being nearly cylindrical. It is 160 mm. long, 35 mm. wide at midlength, ten cameras occupy a length of 93 mm., and the lines of junction with the septa form angles of about 80 degrees with the longitudinal axis of the specimen.

48. **Caliculospongia pauper,** gen. et sp. nov.

(*Plate VI, Figs. 9A, B, C*)

Sponge small and short (13 mm. wide; 21 mm. long), with shallow cloacal cup (7 mm. wide and 3 mm. deep) and with relatively thick walls. Base apparently with short, blunt, subradiciform angulations. Entire sponge perforated by numerous tubular canals, about a quarter of a millimeter in diameter. Within the cup the canal openings tend toward arrangement in lines, chiefly horizontally, about 3 or 4 openings in a distance of 2 millimeters. On the exterior of the sponge no tendency toward linear arrangement is noticed. Under a lens, the surface of the sponge appears dense, and no spicular or fibrous structure is seen. The sponge material often is slightly raised along the margin of the canal openings. The canals often approach the surface very obliquely, and the surface of the sponge, therefore, appears marked by tortuous channels and intermediate ridges. The path of the canals, from the interior of the sponge toward its exterior, also is very irregular.

Found in the Millersburg member of the Cynthiana formation, along the Belt line of railroad, opposite the Magoffin estate, in the northeastern part of Lexington, Kentucky.

49. **Carneyella and Isorophus,** gen. nov.

Among the Ordovician species usually referred to the Devonian genus *Agelacrinites* it is possible to distinguish several groups, for two of which the terms *Carneyella* and *Isorophus* are here proposed. The type of *Carneyella* is *Agelacrinus pileus,* Hall, from the Maysville formation of Ohio, Indiana, and Kentucky. The type of *Isorophus* is *Agelacrinus cincinnatiensis,* Roemer, from the same

formation and area, extending its range into western Tennessee. In *Carneyella* the five plates occupying the interradial angles differ in form from the lateral covering-plates characterizing the rays; this is true especially of the two anterior and of the conspicuous posterior supra-oral plates (1872, Hall, 24th Rep. N. Y. St. Mus., pl. 6, figs. 8, 9; 1914, Foerste, Bull, Denison Univ., 17, pl. 1, fig. 5B). In *Isorophus* the spura-oral plates differ only slightly from the lateral covering-plates of the rays, and the genus is regarded as more primitive in type. To *Isorophus* are referred *Agelacrinus cincinnatiensis*, Roemer, *Agelacrinus holbrooki*, James, and *Lebetodiscus inconditus*, Raymond. In all of these species accessory covering-plates are present along the median line of the rays. To *Carneyella* are referred *Agelacrinus pileus*, Hall, *Agelacrinus billingsi*, Chapman, *Lebetodiscus chapmani*, Raymond, *Lebetodiscus youngi*, Raymond, *Lebetodiscus platys*, Raymond, *Lebetodiscus multibrachiatus*, Raymond, and *Agelacrinus vetustus*, Foerste. None of these species possess accessory covering-plates along the median line of the rays. On that account it is suspected that *Agelacrinus austini*, Foerste, in which the supra-oral area is not distinctly preserved, will prove to belong to the *Isorophus* group.

In *Lebetodiscus dicksoni*, Billings, and *Lebetodiscus loriformis*, Raymond (1915, Raymond, Ottawa Naturalist, p. 53), all the rays are contra-solar. The supra-oral plates differ from the lateral covering plates of the arms merely in their smaller size. From the median ridge of the covering-plates short ridges extend off laterally, excepting at the tip of the plates, where the median ridge broadens out. There are no accessory plates along the median line of the rays.

The name *Carneyella* is proposed in recognition of the valuable contributions of Prof. Frank Carney to physical and glacial geology.

PLATE I.

Fig. 1. STROMATOCERIUM GRANULOSUM James (=Str. huronense Billings) .... p 299
Type of Alveolites granulosus James, No. 2250, in the James collection at Chicago University. From the Waynesville member of the Richmond group, at Clarksville, Ohio.

Fig. 2. DERMATOSTROMA GLYPTUM Foerste .... p 298
Type belonging to the collection of Dr. George M. Austin, of Wilmington, Ohio. From upper part of Whitewater member of Richmond group, on Dutch creek, northwest of Wilmington Ohio.

Fig. 3. DERMATOSTROMA PAPILLATUM James .... p 297
Specimen growing on Byssonychia. From the Clarksville division of the Waynesville member of the Richmond group, at Clarksville, Ohio.

Fig. 4. DERMATOSTROMA SCABRUM James .... p 297
Specimen growing on Byssonychia. From the Waynesville member of the Richmond group. Collection of Dr. George M. Austin, at Wilmington, Ohio.

PLATE I

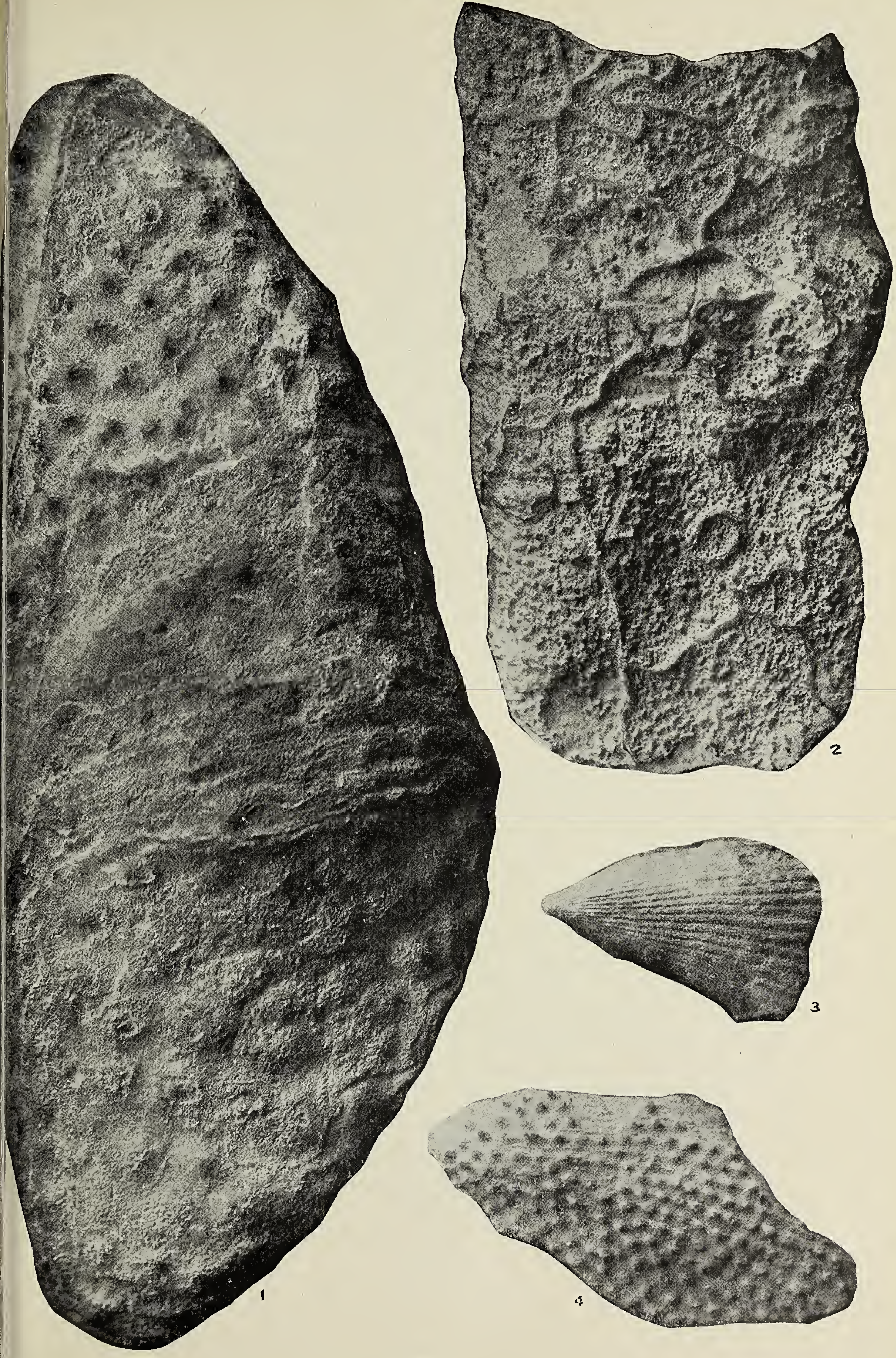


PLATE II.

Fig. 1. STROMATOCERIUM MONTIFERUM Ulrich (=Str. huronense Billings) . . . . p 301

Type of Labechia montifera Ulrich, preserved in the collection of Geo. K. Greene, at New Albany, Indiana. From the Saluda member of the Richmond group, at Madison, Indiana.

Fig. 2. LEPTOPOTERION FABERI Miller (=L. mammiferum Ulrich) . p 291

Type of Chirospongia faberi Miller. A, natural size; B, one of the elevations enlarged. In this type, the short vertical striae, regarded as parts of spicules, are better preserved than indicated in the enlarged figure here presented. No. 8827, in the Faber collection at Chicago University. From the Corryville member of the Maysville group, at Cincinnati, Ohio.

Fig. 3. PROTARÆA VETUSTA Hall . . . . p 292

Type of Porites ? vetusta Hall, No. 642, in the American Museum of Natural History, in New York City. From the base of the Trenton, at Watertown, New York.

PLATE III.

Fig. 1. PASCEOLUS TUMIDUS James (=P. darwini Miller) . . . . p 287

Specimen showing stellate grooving of plates. One of the cotypes, No. 1222, in the James collection at Chicago University. Middle of Maysville group, at Cincinnati, Ohio.

Fig. 2. PASCEOLUS CLAUDEI Miller . . . . p 287

One of the cotypes, No. 8837, in the Faber collection at Chicago University. Base of Bellevue member of Maysville group, at Maysville, Kentucky.

Fig. 3. DYSTACTOSPONGIA ? CAVERNOSA n. sp. . . . . p 290

From Cincinnati, Ohio. Label lost, but probably from middle of the Maysville group.

Fig. 4. DYSTACTOSPONGIA MADISONENSIS Foerste . . . . p 290

Specimen found seven feet above chief Columnaria bed at base of the Saluda member of the Richmond group, at Madison, Indiana.

Fig. 5. CALAPŒCIA CRIBRIFORMIS Nicholson (=C. huronensis) . . . . p 293

Type, No. 216, in the James collection at Chicago University. Probably from the Richmond group at some unknown locality in Ohio.

Fig. 6. LINGULA VANHORNEI Miller . . . . p 306

Pedicel valve, partly exfoliated, showing the vascular branches anterior to the muscular area. Type, No. 8865, Faber collection at Chicago University. Lower Richmond, at Versailles, Indiana, probably from the Waynesville member.

PLATE II

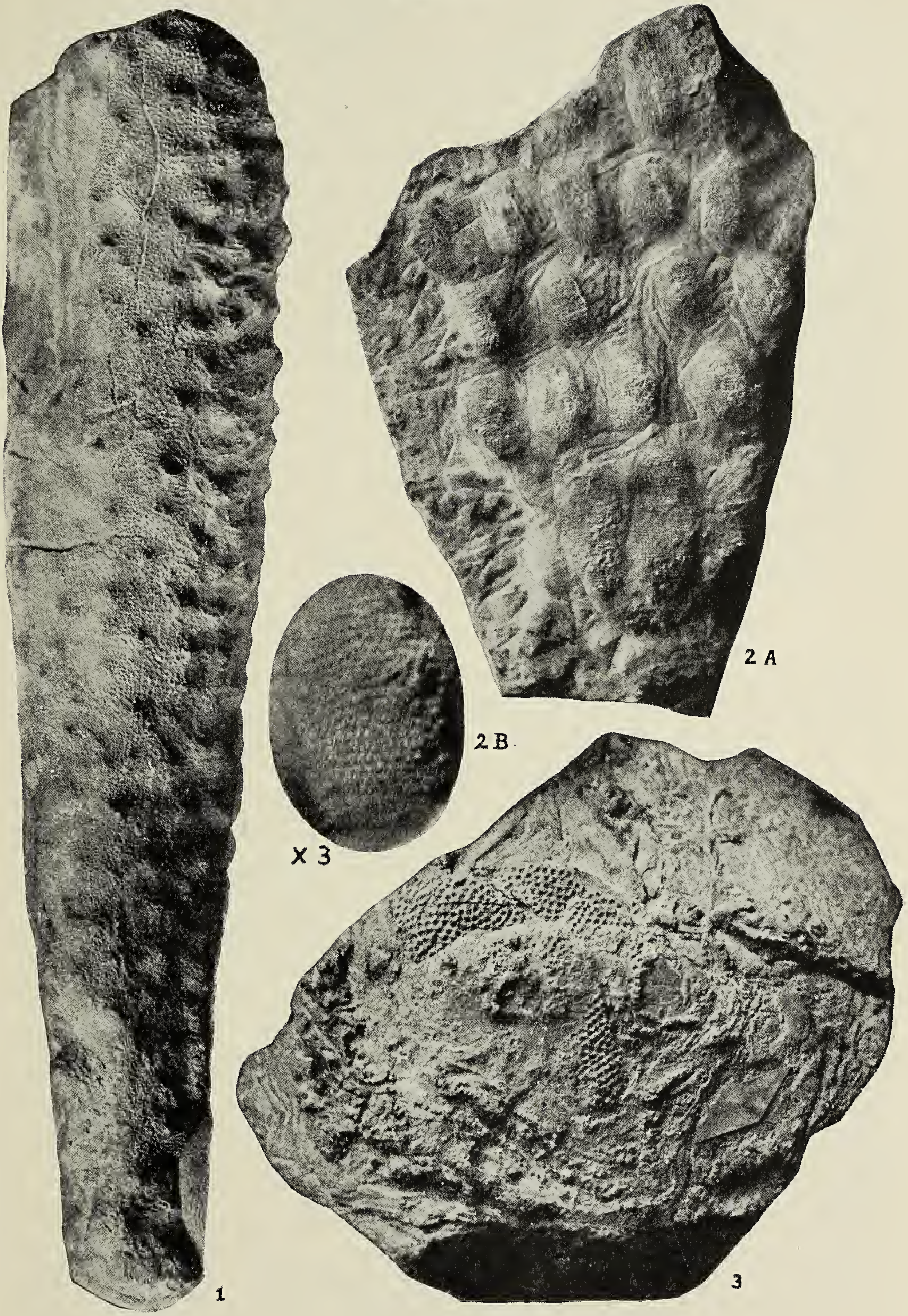


Fig. 7. LINGULA COVINGTONENSIS Hall and Whitfield............p 305
The lower left margin of this figure should be rounded like the margin on the right side. Type, No. 139, in the James collection at Chicago University. Figure, slightly enlarged, prepared from cast of more or less exfoliated interior of valve. Upper part of the Cynthiana group, at West Covington, Kentucky.

Fig. 8. CRANIA ALBERSI Miller and Faber........................p 322
A, enlarged 2 diameters; B, enlarged 4 diameter. Type, No. 8863, in the Faber collection at Chicago University. In the Economy member of the Eden group, at Cincinnati, Ohio.

Fig. 9. CRANIA ASPERULA James (=Cr. scabiosa Hall)............p 314
A, natural size, B, enlarged. Posterior margin along upper right hand margin of figure. Photographed obliquely so as to show the plications crossing the upper valve. Type in the Welch collection, in Wilmington college, at Wilmington, Ohio. Base of Liberty member of Richmond group, at Clarksville, Ohio.

Fig. 10. CRANIA ALTERNATA James (=Cr. scabiosa Hall)..........p 315
A, natural size; B, enlarged. Type, No. 1557, James collection, Chicago University. Upper or Blanchester division of Waynesville member of Richmond group, at Blanchester, Ohio.

Fig. 11. CRANIA SOCIALIS Ulrich................................p 321
A, group attached to crinoid stem, natural size; B, enlarged. Typical specimen, No. 8868, in the Faber collection at Chicago University. Eden group, atCincinnati, Ohio.

Fig. 12. TREMATIS ? FRAGILIS Ulrich..........................p 311
Specimen figured as Trematis punctostriata by Hall and Whitfield, Pal. Ohio, 2, 1873, pl. 1, Fig. 9 (not Tr. punctostriata Hall, 1873, from Clifton, Tennessee). No. 102, James collection. Chicago University. Probably from Eden group, Cincinnati, O.

Fig. 13. CRANIA MULTIPUNCTATA Miller (=Crania scabiosa Hall).p 313
A, natural size; B, enlarged. Type, No. 8869, in Faber collection at Chicago University. From the upper half of the Maysville group at Cincinnati, Ohio.

Fig. 14. TREMATIS FRAGILIS Ulrich.............................p 311
Pedicel valve. Probably from the Eden group, Cincinnati, O.

Fig. 15. CRANIA COSTATA James (=Cr. scabiosa Hall)............p 314
Posterior margin, near lower left hand margin of figure. Photographed so as to show the plications on the upper valve. Type, in Welch collection, deposited in Wilmington college, at Wilmington, Ohio. Probably from some part of the Richmond group, near Clarksville or Wilmington, Ohio.

Fig. 16. TREMATIS FRAGILIS Ulrich.............................p 311
Brachial valve, associated with pedicel valve, figure 14.

Fig. 17. LINGULOPS NORWOODI James.
Type of Lingula norwoodi James, No. 623, in James collection at Chicago University. A, slightly reduced; B, enlarged 2 diameeters. From the upper part of the Cynthiana formation at West Covington, Kentucky, opposite Cincinnati, Ohio.

PLATE III

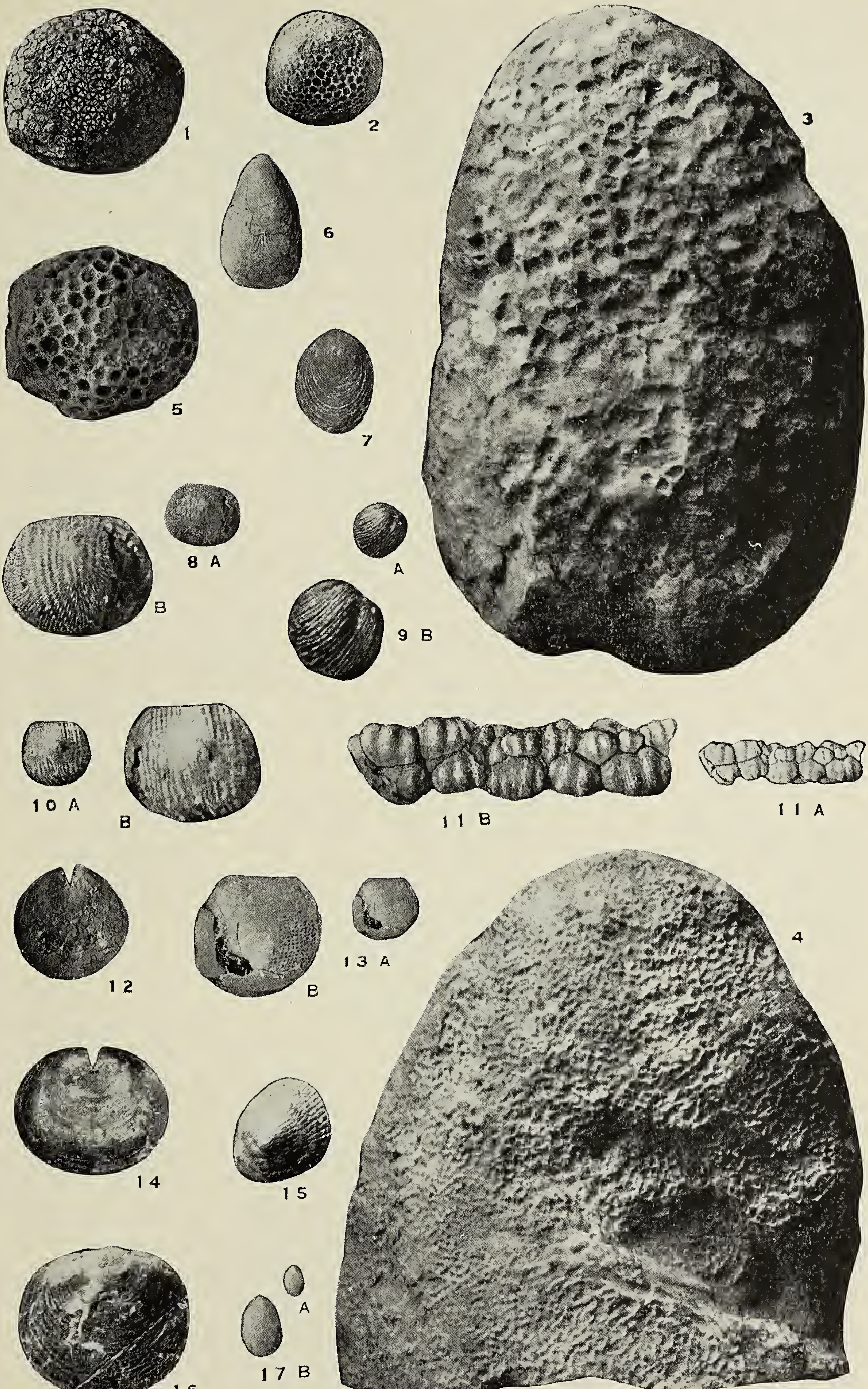


PLATE IV

Fig. 1. BYSSONYCHIA ROBUSTA Miller........................p 328
Type of Ambonychia robusta Miller, No. 8816, in the Faber collection at Chicago University. A, right valve, chiefly interior cast (=Fig. 3 accompanying original description). B, left valve of same specimen. C, anterior view of a second specimen (=Fig. 3a accompanying original description). Base of Saluda member of Richmond group, at Versailles, Indiana.

Fig. 2. ANOMALODONTA ALATA Meek..........................p 326
Right valve. Waynesville member of Richmond group, on Clifty Fork, west of Madison, Indiana.

Fig. 3. ANOMALODONTA COSTATA Meek......................p 328
Type of Ambonychia costata Meek, No. 790, in the James collection at Chicago University. Left valve, with indication of posterior outline drawn from lines of growth on other specimens; the type exposes chiefly the cast of the interior. Possibly from the Arnheim member of the Richmond group at Cincinnati, Ohio, but the species ranges upward also into the Waynesville member of the Richmond.

Fig. 4. MODIOLOPSIS VERSAILLESENSIS Miller................p 331
Left valve, No. 8791, in Faber collection at Chicago University (=Fig. 18 accompanying original description). Waynesville member of the Richmond group, at Versailles, Indiana.

Fig. 5. LINGULA VANHORNEI Miller............................p 306
Type, No. 8865, In the Faber collection at Chicago University. Largely exfoliated, showing parts of interior. A, pedicel valve, with shell retained toward beak and along right margin. B, brachial valve, with shell retained toward beak and along left half. Both figures magnified 3 diameters and retouched so as to accentuate the details of the interior markings. C, vertical outline of shell. Waynesville member of the Richmond group at Versailles, Indiana.

Fig. 6. LINGULA BROOKVILLENSIS nov. sp....................p 308
A, pedicel valve; B, brachial valve. Both figures magnified 3 diameters, and retouched so as to accentuate the details of the interior markings. C, vertical outline of shell. Found at Boundary Hill, along railroad, two miles west of Brookville, Indiana. Probably from the Arnheim member of the Richmond group.

Fig. 7. CRANIA PERCARINATA Ulrich..........................p 317
Enlargment of part of the striæ crossing the upper valve of Crania percarinata, in order to indicate the former attachment of this type to the peripheral border of a Lophospira. Same specimen as that figured on plate VI of this bulletin.

PLATE IV

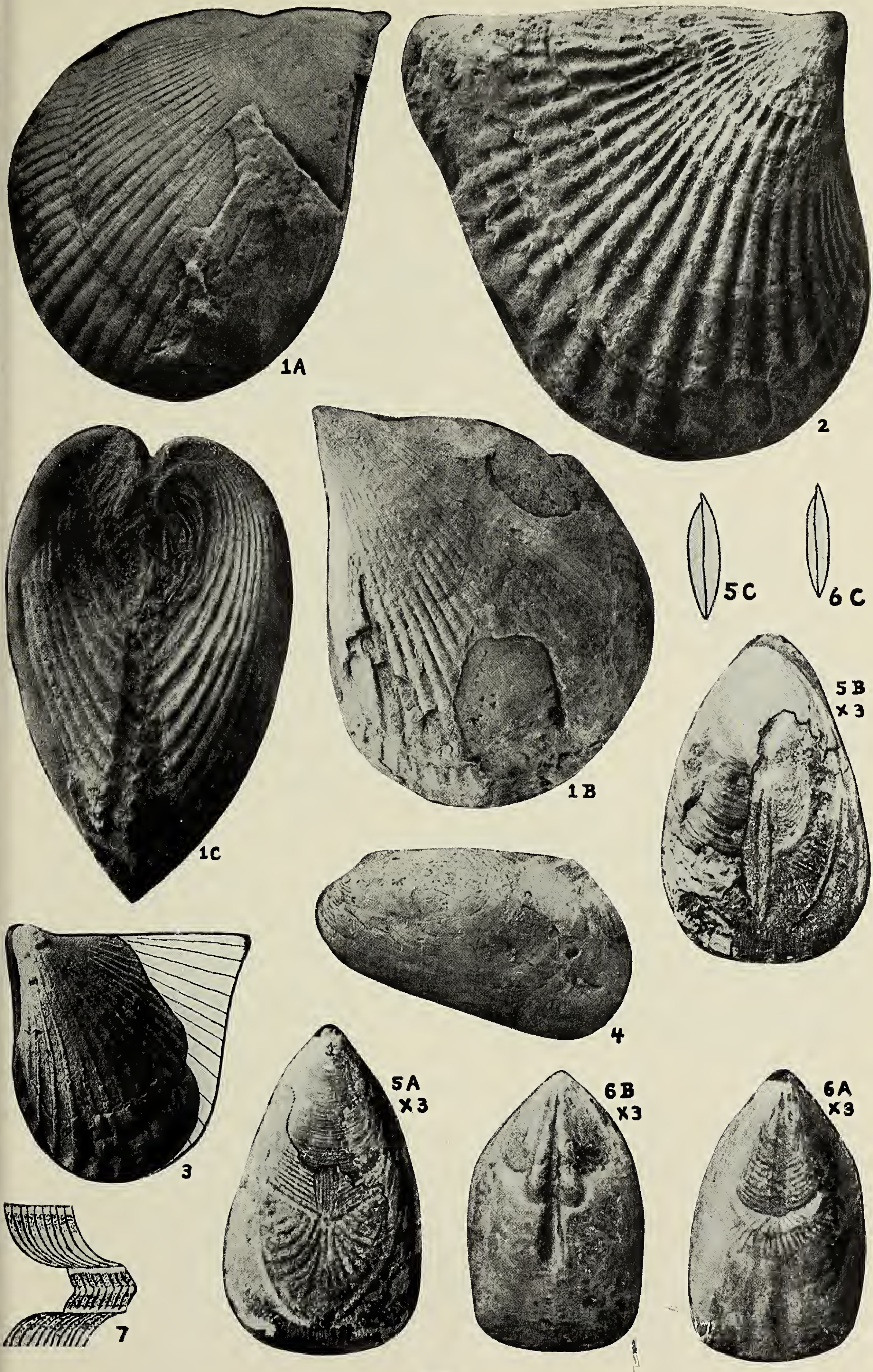


PLATE V

Fig. 1. MODIOLOPSIS BREVANTICA n. sp .... p 332

A, cardinal view; B, left valve. Type. From the Waynesville member of the Richmond group at Clay Cliff, 4 miles south of the end of Cape Smith, on the eastern shore of Manitoulin Island, Ontario.

Fig. 2. PHOLADOMORPHA SULCATA Miller and Faber (=Ph. pholadiformis Hall) .... p 337

Left valve, with several longitudinal folds due to oblique compression within soft shale. Type of Modiolopsis sulcata, No. 8798, in the Faber collection at Chicago University. Labelled as coming from Warren county, Ohio. Probably from the Richmond group.

Fig. 3. PHOLADOMORPHA DIVARICATA Hall and Whitfield (=Ph. pholadiformis Hall) .... p 333

A, left valve; B, cardinal view; C, right valve enlarged. Type of Sedgwickia divaricata, No. 1489, in the James collection at Chicago University. From the upper or Blanchester division of the Waynesville member of the Richmond group, at Blanchester, Ohio.

Fig. 4. PHOLADOMORPHA CAPAX Miller (=Ph. pholadiformis Hall) p 334

A, right valve; B, cardinal view, with anterior end toward the upper part of the figure. Type of Modiolopsis capax, No. 8802, in the Faber collection at Chicago University. From Versailles, Indiana. Probably from the Waynesville member of the Richmond group.

Fig. 5. PHOLADOMORPHA CORRUGATA Miller and Faber (=Ph. pholadiformis Hall) .... p 336

Left valve. Type of Modiolopsis corrugata, No. 8813, in the Faber collection at Chicago University. Labelled as coming from Warren county, Ohio. Probably from the Waynesville member of the Richmond.

Fig. 6. VALLATOTHECA MANITOULINI Foerste .... p 339

Oblique view, with apex toward the lower right hand corner of the figure. Photographed so as to show the concentric lamellose outgrowths of the shell, and the short longitudinally directed striæ, terminating at the free margins of the lamellæ. Magnified about 3.5 diameters. Type, From the Waynesville member of the Richmond group, at Clay Cliff, on the eastern shore of Manitoulin island.

PLATE V

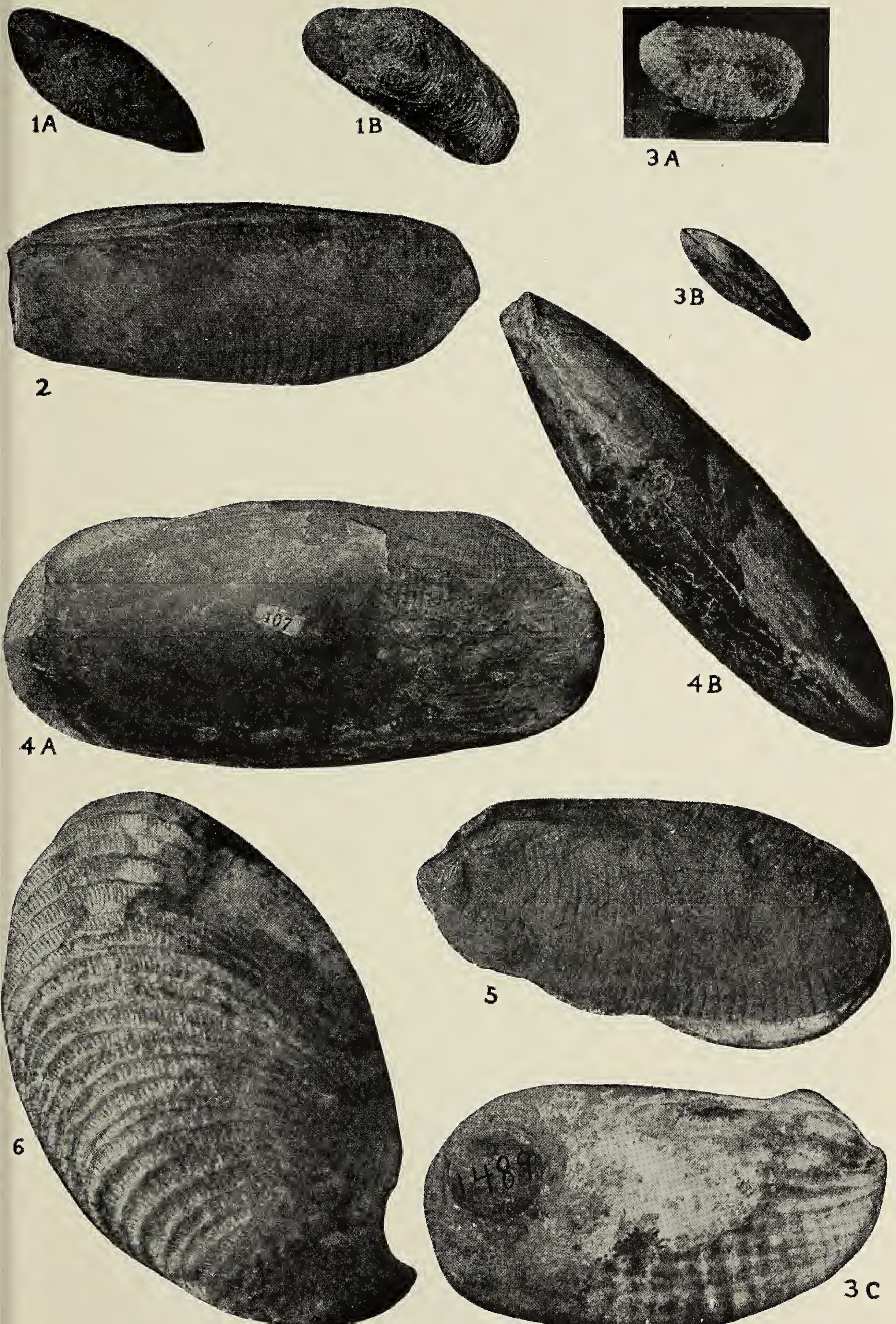


Plate VI

Fig. 1. CRANIA PERCARINATA Ulrich........................p 317
Type, magnified 3 diameters, in collection of Prof. Charles Schuchert, of Yale University. Reproducing markings of tricarinate peripheral band of Lophospira (See plate IV of this bulletin). Position of figure inverted from that shown in figure 30 on plate 4H, in volume VIII, of the paleontology of New York. From the Economy member of the Eden group, at Covington, Ky.

Fig. 2. CRANIA PARALLELA Ulrich............................p 319
Type, magnified 3 diameters, in collection of Prof. Charles Schuchert, of Yale University. Reproducing markings of Conularia. Specimen with margin broken off along upper part of figure. Economy member of Eden group, at Covington, Ky.

Fig. 3. CRANIA PARALLELA Ulrich............................p 319
One of the series of types in the collection of Prof. Charles Schuchert of Yale University. Specimen not figured heretofore, magnified 3 diameters. This specimen reproduces the markings of some shell, possibly the interior markings of a brachial valve of Plectambonites. In addition to this, the surface is marked by numerous short radiating striæ, too minute to be reproduced in the figure. Economy member, Eden group at Covington, Ky.

Fig. 4. CRANIA SOCIALIS Ulrich..............................p 321
Type figured by Ulrich, magnified 3 diameters, in the collection of Prof. Charles Schuchert of Yale University. Reproducing outlines of the columnals of a crinoid stem. From lower half of Eden group, in the vicinity of Cincinnati, Ohio.

Fig. 5. TREMATIS PUNCTOSTRIATA Hall.....................p 312
Upper valve, enlarged 2 diameters (=Fig. 1, on pl. V, of vol. XVI, of this bulletin). From the Saltillo member of the Trenton group, at the type locality, Clifton, Tennessee.

Fig. 6. TREMATIS CRASSIPUNCTATA Ulrich.................p 311
Type, magnified 3 diameters, in collection of Prof. Charles Schuchert of Yale University. From Fairmount member of Maysville group, at Cincinnati, Ohio.

Fig. 7. CYMATONOTA CYLINDRICA Miller and Faber (=C. typicalis Ulrich)...p 330
Type of Orthodesma cylindricum, No. 8801 in the Faber collection at Chicago University. A, left valve; B, dorsal view, showing oblique plications along the hinge-line. Probably from the Waynesville member of the Richmond group in Warren county, Ohio.

Fig. 8. RHYTIMYA CYMBULA Miller and Faber (=Rh. mickleboroughi Whitfield)....................................p 338
Type of Orthodesma cymbula, No. 8814, in the Faber collection at Chicago University. Defective at anterior and posterior extremities. A, left valve; B, dorsal view. From the Fairmount member of the Maysville group at Cincinnati, Ohio.

PLATE VI

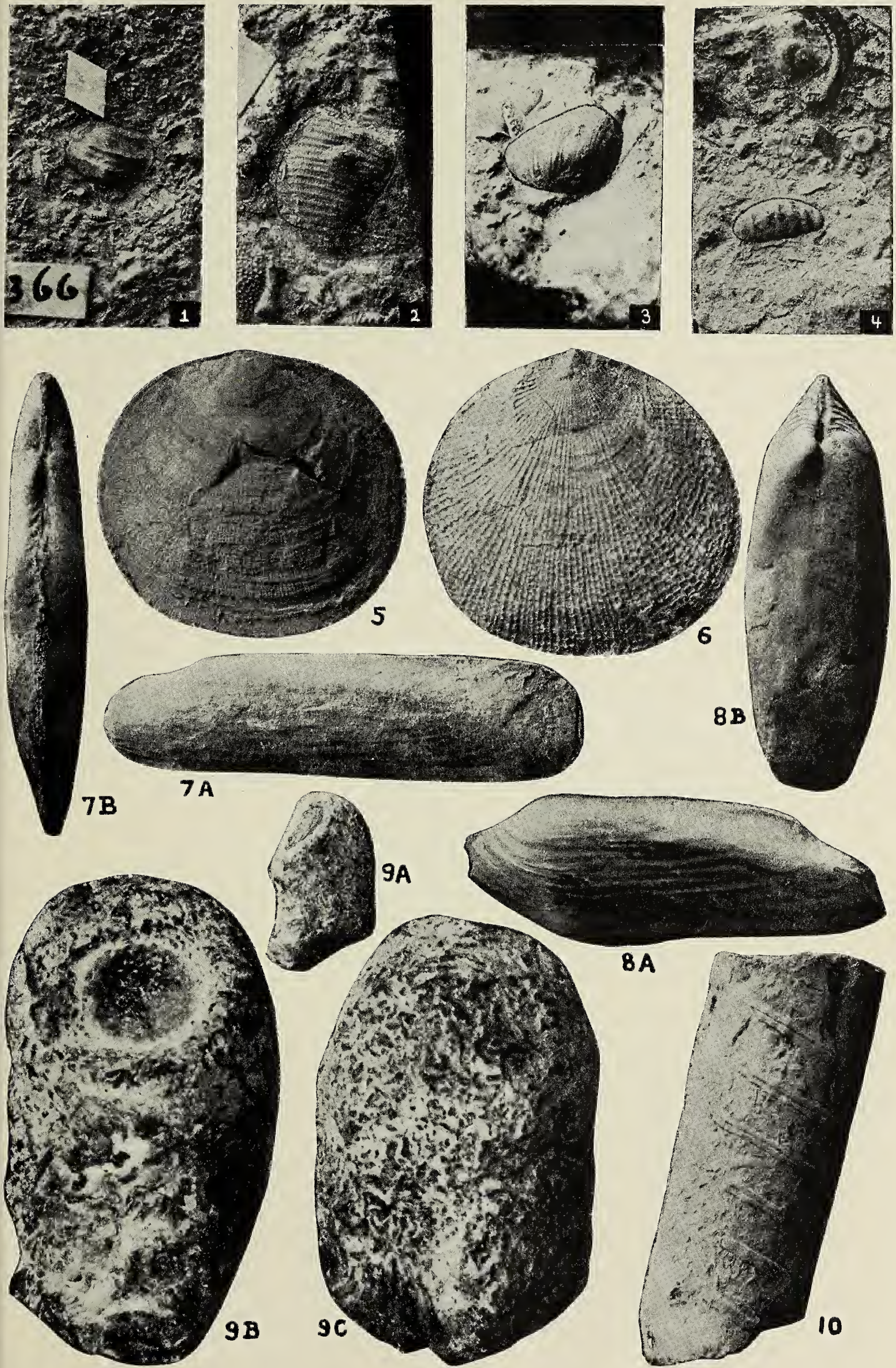


Fig. 9. CALICULOSPONGIA PAUPER gen. et sp. nov. . . . . p 348

A, natural size, with cloacal cup at top seen diagonally from the side; B, same, with cloacal cup seen from the front, enlarged 3 diameters; C, same, viewed from the opposite side, showing the tortuous canals, enlarged 3 diameters. From the upper part of the Trenton group, along the belt line railroad at the Magoffin place, in Lexington, Kentucky.

Fig. 10. ENDOCERAS sp . . . . p 339

One of two specimens labelled Colpoceras arcuatum in the James collection at Chicago University and numbered 657. This specimen evidently is a siphuncle which tapers so much less than the type described by James that it must belong to a different species. The type of Colpoceras arcuatum also consisted of a siphuncle of some species of Endoceras. From the lower part of the Maysville group, at Cincinnati, Ohio.

PLATE VII

Fig. 1. WHITELLA CUNEIFORMIS Miller . . . . p 323

Type of Orthodesma and Sphenolium cuneiforme Miller, No. 8803, in the Faber collection at Chicago University. A, right valve, imperfect, especially along the anterior and posterior margins; B, same, dorsal view; c, an attempt at a restoration of the original form of the type. Versailles, Indiana, probably from the Waynesville member of the Richmond group.

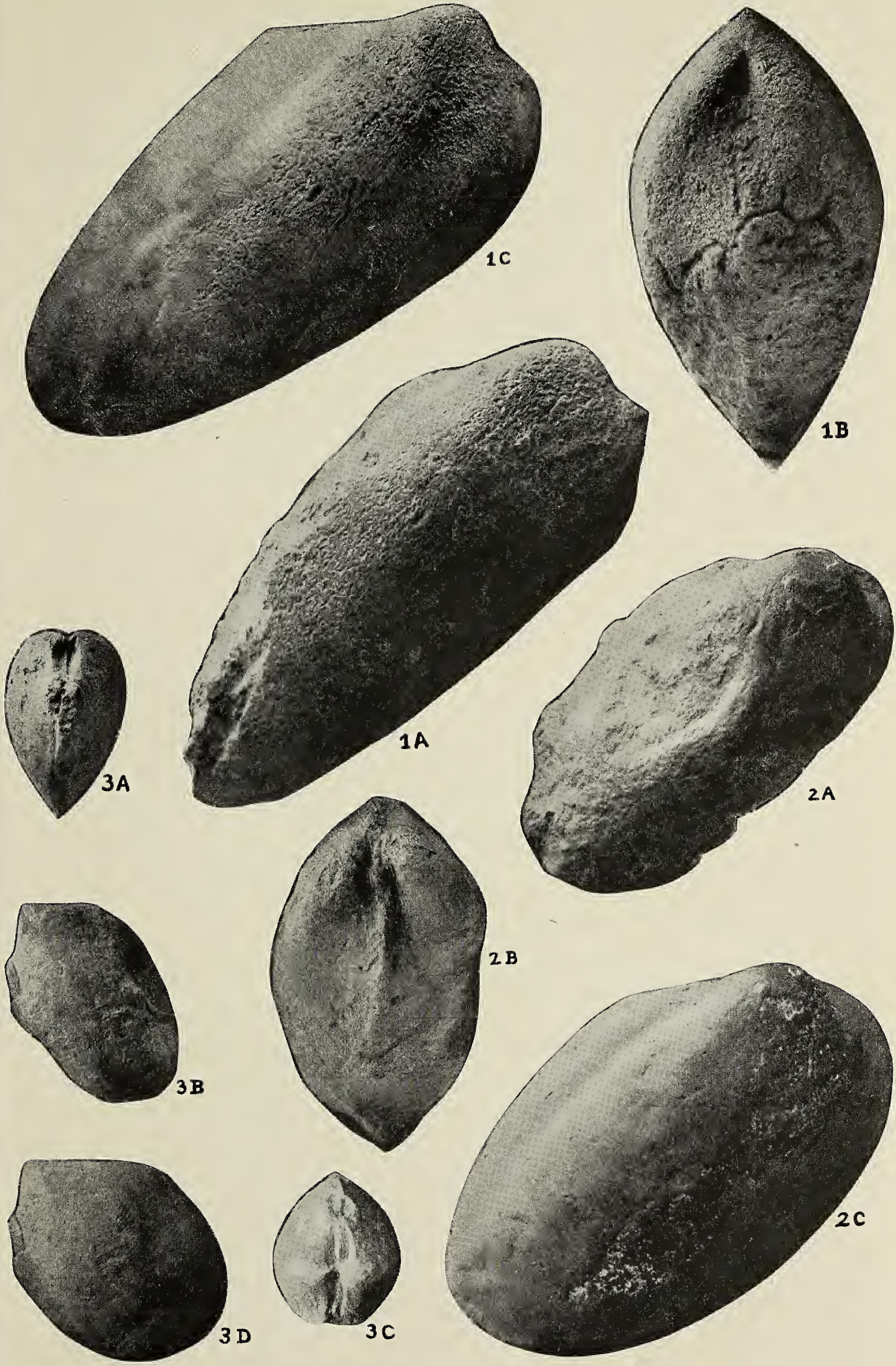
Fig. 2. WHITELLA RICHMONDENSIS Miller . . . . p 324

Type of Sphenolium richmondense Miller, No. 8800, in the Faber collection at Chicago University. Imperfect, especially posteriorly. A, right valve; B, same specimen, dorsal view; C, an attempt at a restoration of the original form of the type. Richmond, Indiana, probably from the Whitewater member of the Richmond group.

Fig. 3. CYRTODONTA CUNEATA Miller . . . . p 326

Type of Angellum cuneatum Miller, No. 8815, in the Faber collection at Chicago University. Imperfect, and artificially carved so that it may never be possible to identify the species. Especially imperfect along the anterior and posterior margins. A, anterior view; B, lateral view; C, dorsal view; D, an attempt at a restoration of the original form of the type, excepting at at the anterior extremity. Richmond, Indiana, probably from the Whitewater member of the Richmond group.

PLATE VII



THE SHORELINES OF GLACIAL LAKES LUNDY, WAYNE, AND ARKONA, OF THE OBERLIN QUADRANGLE, OHIO[1]

Frank Carney

Six years ago in this Bulletin, vol. 16, pp. 101-117, the writer published a map of, and described, the glacial lake shorelines of the Oberlin quadrangle. Some of the beaches mapped were of doubtful interpretation, being too high or too low to conform to the shorelines then well-understood. The presence of other fragmentary beaches was not suspected, and accordingly not investigated.

During the past year, parts of this area have been re-visited, and other parts studied, in the light of progress made elsewhere in mapping the shorelines of former glacial lakes. So many corrections and alterations have been made that it is advisable to publish a new map.

In a later issue of this Bulletin, a brief résumé of proglacial lake history was published (vol. 17, 1913, pp. 234-236); certain alterations are required in this résumé, chiefly thru the work of Leverett and Taylor (Monograph 53, U. S. Geol. Survey, 1915) who have ascertained more precisely the positions and altitudes of the outlets of the ice-front lakes, and the oscillations of the glacier margin associated with the several lake stages. The alterations required are principally in giving a wider range of altitude to the various lake stages; these are shown in Fig. 1 in which the submerged shorelines are indicated by broken lines.

Each retreat of the glacier was apt to uncover a lower outlet for the water ponded in front of the ice, resulting in a drop of the lake level, as when the glacier in the Huron basin withdrew far enough to uncover an outlet across the "thumb" of Michigan (the land between Saginaw Bay and Lake Huron), the first Lake Maumee, which overflowed by way of Fort Wayne, Ind., ceased to exist, and the lowest Maumee stage was formed. Later the ice readvanced, covering the outlet of the lowest Maumee and causing the water to rise over the shoreline which that lake stage had developed, thus inaugurating the lake which produced the "middle" Maumee shoreline. During the existence of this stage, the beach previously made stood beneath

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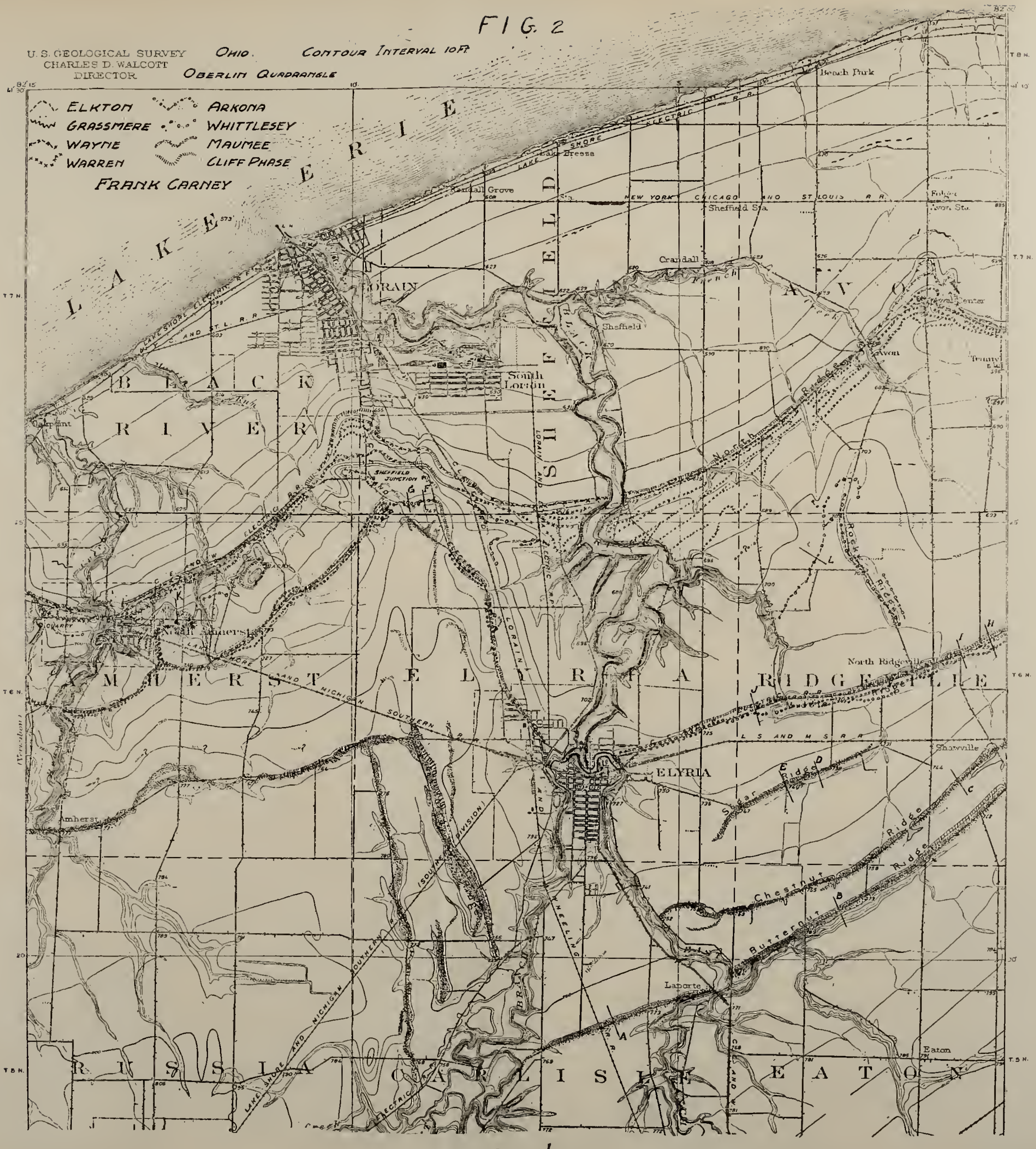
FIG. 2



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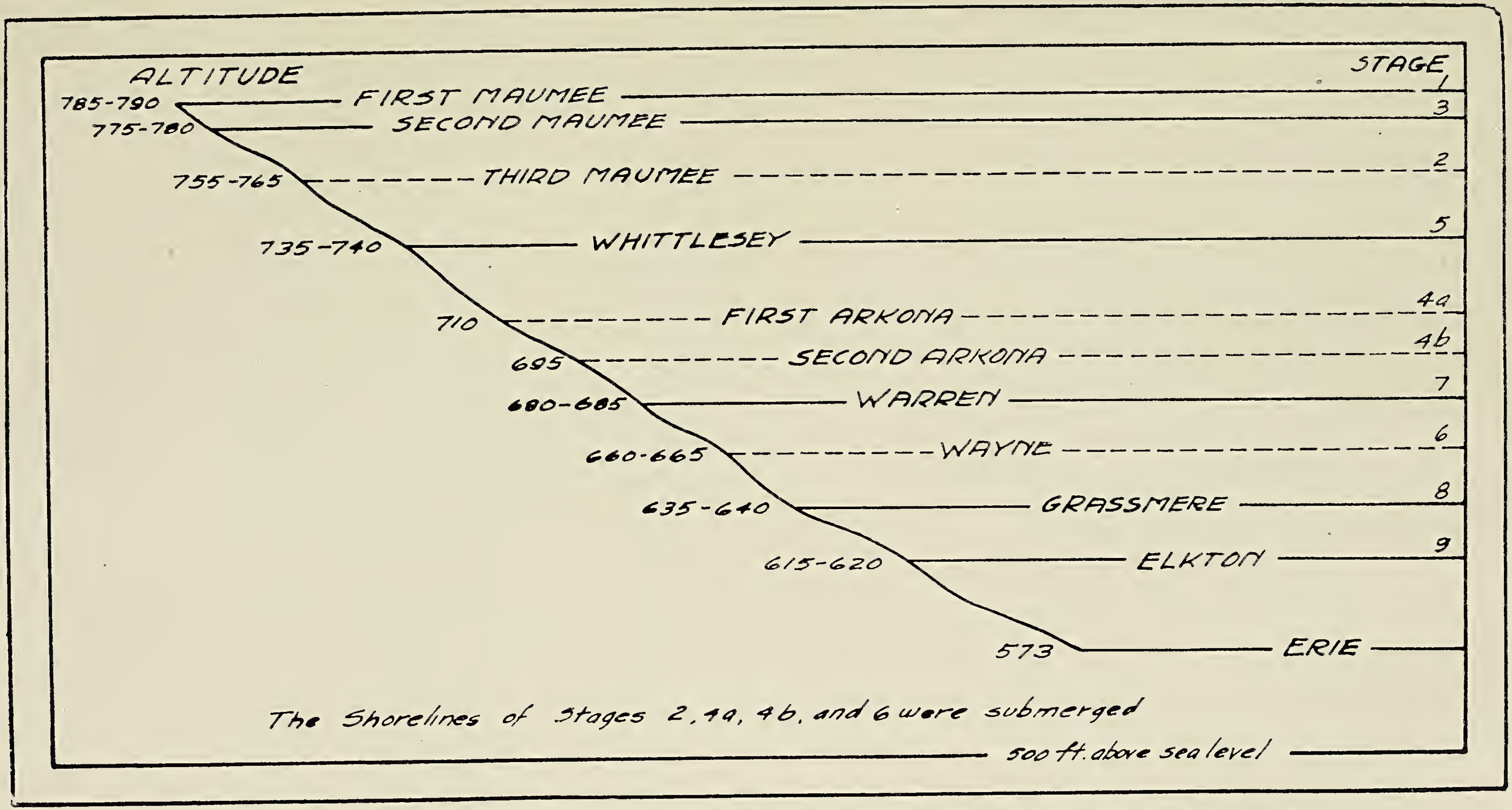


Fig. 1. Altitudes are based on the work of F. B. Taylor (Monograph 53, U. S. Geol. Survey).

water and was altered in several ways: (1) in some localities it was eroded by waves and currents, becoming fragmentary instead of being nearly continuous as abandoned beaches usually are; elsewhere it was washed down and flattened in cross-section; (2) the covering of water protected the beach from some phases of weathering, but emphasized others; (3) the water from the melting glacier contained much clay which filtered into the submerged beach and made it "stiffer and more firm than the ordinary beach soil."

The "middle" of the three Maumee stages was terminated by a retreat of the glacier; then the lake, lowered by about 70 feet, began to escape thru a depression near Maple Rapids, Mich. (Taylor, Monograph 53, p. 363), initiating Lake Arkona. Another readvance of the ice closed the Maple Rapids outlet and the level of the water was raised about 35 feet, forming Lake Whittlesey, and submerging the Arkona beaches. Again the glacier front withdrew and Lake Wayne came into existence. Lake Warren was the next in the series; this stage resulted from a forward movement of the ice, closing the Wayne overflow channel and submerging the Wayne shoreline. Then the glacier front must have remained fairly stationary for a long time, as the Warren shoreline has a strong development. The next retreat of the ice margin uncovered an outlet about 50 feet lower in altitude, and Lake Lundy was established, the lowest of the lake stages which may be seen in Ohio.

Lake Lundy

Elkton Stage. A few segments of this shoreline have been indicated on the Oberlin quadrangle. Proceeding westward from the east side of the sheet, the first segment, about 15 rods long, is met half way between Avon Station and the Lake Shore Electric Railroad. After a gap of one-half mile the beach reappears about three-fourths of a mile northwest of Avon Station, as a broad ridge, in places six or seven feet high, of fine gravel and sand. About two miles west of Sheffield Station is another remnant of this shoreline, shorter and less distinct. Careful study of the area between this and the Black River, as well as west of the Black River, did not show any further beach structures. At the proper horizon for the Elkton shoreline the ground moraine bears a conspicuous number of bowlders which generally rest almost directly upon the Erie shale. The general levelness of the area, together with the relatively short duration of

this lake stage, probably account for the scanty shoreline development.

Grassmere Stage. About one-quarter of a mile south of Avon Station, a low sandy ridge, approximately 80 rods in length, is the only beach structure, belonging to this stage, found east of the Black River. Coincident approximately with the correct altitude for this shoreline, the clay of the till has been removed, concentrating the bowlders. Between Black River and North Amherst the fields show a sandy soil, but nowhere was a beach form noted. West of Beaver Creek, commencing near its bank, a broad low sandy ridge, about 100 rods in length, crossed by the first north-south highway west of North Amherst, is the last evidence of the Grassmere shoreline noted on this quadrangle. The conditions suggested above for the slight development of the Elkton shoreline probably hold also in the case of the Grassmere.

Lake Wayne

Commencing on the east side of the Oberlin quadrangle this stage is marked by a low sandy beach as far west as Avon. North of Avon Center, the northernmost of the beaches which are associated with the cuspate foreland, belongs to Lake Wayne; the margin of this foreland has been subject to wave-erosion, as shown by the fact

Fig. 3. Bowlder strewn area along the Wayne shoreline northeast of Avon Center.

that the Berea sandstone for three-eighths of a mile is quite bare, and the fields contain numerous glacial boulders (Fig. 2). Between French Creek and Black River the shoreline consists mostly of a cliff cut in the fissile shale. Lying a few rods north of the front of this

cliff, barrier sand formed a lagoon, and, as a result, the fields contain a long narrow strip of muck soil paralleling the shoreline.

For about one-half mile west of Black River the cliff phase continues. This is succeeded by a very distinct sandy beach, in places rising five feet above the bordering plain. Approaching the Wheeling Railroad, the Wayne beach bears northward and continues as a deposit of sand. About 60 rods north of the point where the railroad crosses the shoreline, a steep slope in the rock marks its horizon; this condition persists for nearly 100 rods, when the shoreline again becomes a beach. South of Lorain the cuspate foreland of Lake Warren is bordered by a cliff cut in the Berea sandstone; several segments of beach, barrier structures of the Warren stage, mark the top slope of this cliff.

Westward of the foreland, structural deposits again indicate the Wayne level. With the exception of a few segments, however, this shoreline, beyond the point where it is intersected by the electric railroad, consists of a cliff; further evidence of wave-work is seen in the band of bowlders which parallels the cliff; west of Beaver Creek, for about one-third of a mile, the Lake Shore Railroad parallels the beach deposits of the Wayne stage. The last one-quarter of a mile on the sheet consists of a cliff cut in the Berea sandstone.

Lake Arkona

South of Trinity, just beyond the angle in the highway, a few rods of ridged sand and gravel may indicate the 695-foot stage of Lake Arkona. For a little over a mile directly west, the fields do not give any definite shoreline evidence. Commencing a short distance west of the highway which runs south from the North Ridge one and one-half miles west of Avon an indistinct sandy gravel-ridge, lying somewhat above the 690-foot contour, may be traced quite continuously to the Black River; for a part of this distance there are two low ridges about 40 rods apart.

On the west border of the bay which occupied the Black River valley depression more definite evidence of this stage was noted. Near the north boundary of Elyria township, between the Lorain and Elyria Electric R. R., and the Cleveland, Lorain and Wheeling R. R., the countours bend to the east around an outlier of Berea sandstone; from this outlier a spit grew southeastward, and is cut thru by the electric line; north of the outlier an accumulation of sand extends for about three-fourths of a mile; thence through a half-mile interval the fields show much sandy gravel, but no ridge.

The steepened slope just north of Sheffield Junction may represent wave-work of Lake Arkona. North of the quarry, marked on the map one mile east of North Amherst, the lower Arkona is probably indicated by an accumulation of sand piled against the flank of this outlier. In the vicinity of North Amherst the fields are sandy at this horizon but no beach exists. West of the Beaver Creek a sand beach, approximately one-third of a mile long, marks this shoreline.

The 710-foot stage of Lake Arkona is registered on either flank of Rocky Ridge which is traversed by the highway extending north from North Ridgeville. For about one-third of a mile, paralleling the southern end of this ridge, a fine gravel beach is indicated. Elsewhere on the east flank, a bare slope of rock registers the Arkona wave-work. On the coast of Lake Arkona this ridge formed a cape, the lake end of which is marked by a broad accumulation of sandy gravel which lies athwart the highway. On the west side of the cape's crest is a beach ridge extending nearly its entire length; this ridge may be the result of storm waves, as the cape was exposed to the west winds. The western border of this cape, save for a few rods near its north end, is indicated by an uninterrupted stretch of beach which terminates near a tributary of the Black River; at location L (Fig. 2) the front slope rises seven feet in a horizontal distance of 200 feet, and the back slope drops three feet. Between this tributary and Elyria no definite evidence of the Arkona was found.

West of the Black River, north of Elyria, a belt of sand at about the proper horizon probably represents the shoreline of this Arkona stage; thence for one mile the only evidence is the thinness of the drift; a clear cut beach deposit extends for about 100 rods south from the Berea outlier mentioned in an earlier paragraph. Just south of the angle in the highway, a mile directly east of Sheffield Junction, is a one-quarter mile stretch of beach. A short distance north of Sheffield Junction, a strongly developed ridge crosses the highway and terminates in a hook about 80 rods to the west. South of the ridge a swamp existed till drained a few years ago. Mr. Delano who owns the farm says it was necessary to dig a ditch 12 feet deep thru the ridge which was very coarse in texture, but at the bottom was sand, "as fine sand as you can find on the lake shore today." Between this point and North Amherst only a few segments of the shoreline were noticed. West of Beaver Creek the higher Arkona level is marked by a sandy condition of the fields, but no beach or cliff.

THE ABANDONED SHORELINES OF THE ASHTABULA QUADRANGLE, OHIO[1]

Frank Carney

The southern border of the pro-glacial lakes on the Ashtabula Quadrangle was limited by the Painesville moraine. In northern Ohio the distribution and direction of the moraines has also influenced the course taken by many rivers; the Grand River, for example, for several miles flows along the outer border of the Painesville moraine.[2] In this quadrangle the lake plain is from three to five miles wide; the shorelines which cross it are roughly parallel; its surface is trenched by only one river, the Ashtabula, which rises south of the moraine; Wheeler, Cowles and Indian creeks, and Red Brook, have their sources in the moraine; except in their headwater sections, all these streams have low gradients.

Lake Maumee

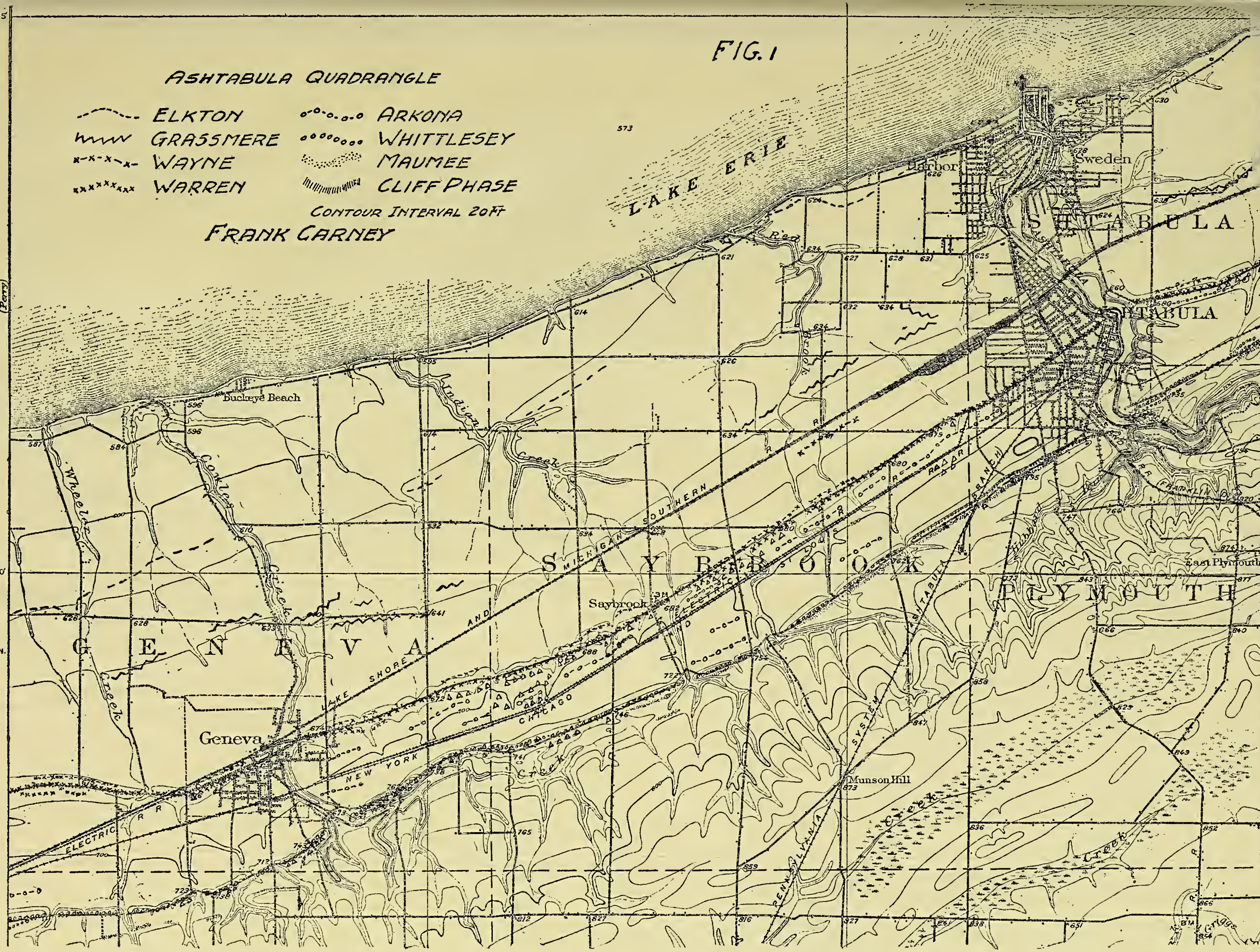
One stage of Lake Maumee is registered across the Ashtabula Quadrangle by a disconnected series of gravel ridges and accumulations of sand. Commencing near the west border of the sheet (Fig. 1) where the north slope of the moraine is low, one notes, about two miles southwest of Geneva, a gravel ridge crossed by the first north-south highway on the sheet; laterally this ridge changes to a cut-bank; its strong development, however, appears to be responsible for the location of a house which stands many rods off the highway. The next two north-south roads to the east also cross slightly ridged gravel suggesting wave origin; the easternmost of these two deposits, that is, the one directly south of Geneva, bears more gravel on its south slope, whereas its top and its north slope in no wise differ from the water-laid materials that frequently characterize moraines.

Southeast of Geneva the top of the slope against which the Whittlesey shoreline is registered, frequently bears gravel belonging to Lake Maumee. A little farther east it seems probable that the dune sand, as shown in Fig. 2, is associated with this lake stage. Directly south of Saybrook, Maumee gravel lies immediately south of

[1]Published by permission of the Geological Survey of Ohio.

[2]Frank Leverett, Monograph XLI, U. S. Geol. Survey, 1902, p. 652.

FIG. 1



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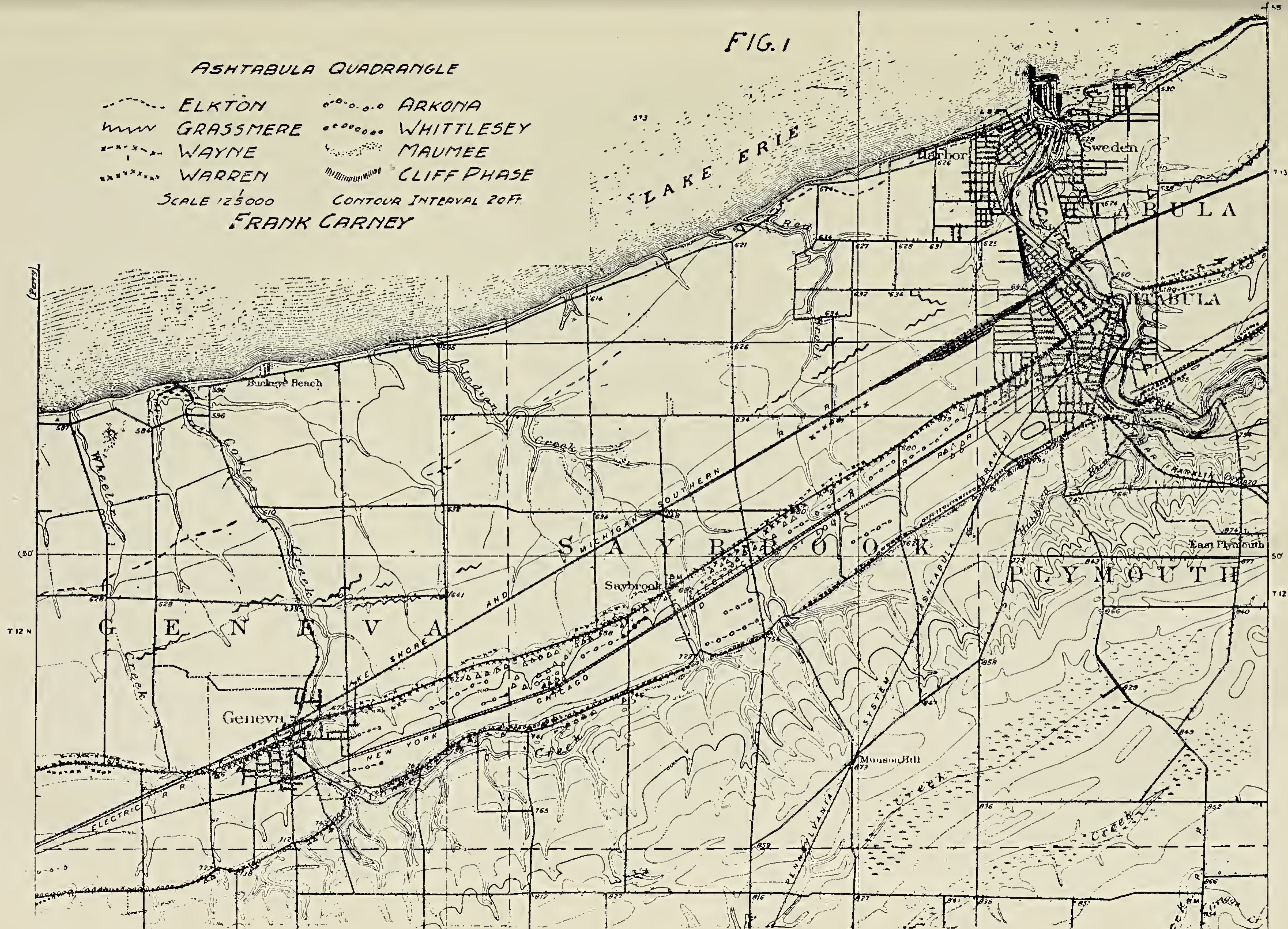

ASHTABULA QUADRANGLE
ELKTON
ARKONA
GRASSMERE
WHITTLESEY
WAYNE
MAUMEE
WARREN
CLIFF PHASE
SCALE 1/125000
CONTOUR INTERVAL 20 FT.
FRANK CARNEY
LAKE ERIE
ASHTABULA
Harbor
Sweden
Buckeye Beach
Geneva
Saybrook
East Plymouth
Munson Hill
GENEVA
SAYBROOK
PLYMOUTH
MICHIGAN SOUTHERN
LAKE SHORE AND
NEW YORK CHICAGO
ELECTRIC R R
PENNSYLVANIA SYSTEM
ASHTABULA
Wheeler Creek
Cowles Creek
Indian Creek
Red Brook
Creek

FIG. 1

the highway; an earlier position of Maumee wave-work is seen in a typically developed ridge about 20 rods farther south. Proceeding eastward, the top of the wave-cut Whittlesey slope bears Maumee sand and gravel continuously to the Ashtabula River. On the east side of the river no evidence of this shoreline is seen until within a few rods of the margin of the sheet, where we find a stretch of shore gravel about an eighth of a mile long.

These segments of the Maumee shoreline range about the 760-foot contour. In places where the sand has been drifted into knolls higher elevations are reached, even 800 feet, as southwest of Ashtabula; the location of such sand is indicated on the map (Fig. 1) by small triangles. Along modern as well as ancient shorelines sand is

Fig. 2. Whittlesey shoreline southeast of Geneva. The irregular sky line is due to knolls of wind-drifted sand belonging to the Maumee beach.

frequently found in knolls or dunes reaching 20 feet, and occasionally 100 or more feet, higher than the general level of that particular water stage. For this reason, the beaches above described may appear in places to indicate a higher Maumee shoreline; the possibility of erroneous interpretation here, because of drifted sand, has been pointed out by Leverett.[3]

Lake Whittlesey

On the Ashtabula sheet the Whittlesey shoreline, about 740 feet in altitude, is a conspicuous topographic feature. It has been sectioned by Cowles Creek a short distance south of Geneva, and by the Ashtabula River in the southern portion of the village of Ashtabula. Its water slope ranges from 10 to 40 feet in height; the back slope of

[3] *Ibid.*, p. 736.

the beach phases of the shoreline is four to eight feet high; locally the shoreline is a cliff cut in the moraine.

In the vicinity of Unionville on the Perry Quadrangle, which is next west of this sheet, the Whittlesey shoreline consists of two beach ridges, both of which continue a short distance eastward into the Ashtabula sheet. For the next mile a beach ridge, consisting of gravel and some fine sand, with a steepened outer slope, marks this shoreline. Where the highway which follows the Whittlesey crosses the east branch of Wheeler Creek, 15½ feet of glacial till is shown in the cut; the steepened slope in the drift becomes more conspicuous eastward toward Cowles Creek. Dunes cap the land slope for a mile west of this creek, and drifted sand is found continuously to the east as far as the meridian of Saybrook; these deposits of sand, as already described, belong to Lake Maumee.

From a point three and one-half miles west of the Ashtabula river the cliff phase of the Whittlesey continues to the river; throughout most of the last two miles, the outer slope is often 40 feet high, as shown in Fig. 3. In the absence of cuts it could not be determined whether rock forms any part of this cliff; the till in the area is probably over 40 feet thick; the Ashtabula branch of the Pennsylvania railroad makes a cut through this shoreline, but so far as observed does not disclose rock. Drifted sand hills of the Maumee level throughout this two mile stretch, are numerous, in one place rising above the 800-foot contour. Near the Ashtabula River the shoreline

Fig. 3. Cliff phase of the Whittlesey south of Ashtabula.

Fig. 4. The Whittlesey beach ridge built on the north face of the Painesville moraine, east of Ashtabula.

swings southward, in the vicinity of the cemetery; it is not likely that any considerable embayment characterized the Whittlesey shore at this point, though a slight depression apparently antedated the present river channel.

Immediately east of the river the shoreline consists of two ridges, for about one-half mile, a condition which also points to the presence of a small bay; in the southern of these two ridges, just west of the highway leading south to the river, a gravel pit has been opened. Thence eastward for nearly a mile, a single beach ridge obtains, built against the moraine (Fig. 4), which, in the early stages of the Whittlesey level, must have suffered much through wave-erosion. Eastward, near the margin of the sheet, the shoreline shows an inner ridge, barrier in origin.

Lake Arkona

Two shorelines, approximately 695 and 710 feet in altitude,[4] mark the levels of Lake Arkona, which was succeeded by Lake Whittlesey. Thus the Arkona beaches were submerged beneath 25 to 40 feet of water. Modified by wave-work and currents, these shorelines are quite indistinct, though in places well-defined beach fragments have withstood the attrition processes, and make it possible to trace the margin of Arkona waters.

East of Ashtabula is a mile segment of beach belonging to the lower stage of Lake Arkona; it is a few rods south of, and parallel with, the Warren beach. For three miles west of Ashtabula, between the Warren shoreline and the Electric railway, the map indicates a

[4]F. B. Taylor, Ann. Rep., Smithsonian Institution, 1912, p. 305.

fairly continuous sandy ridge. Throughout the next three miles westward this horizon of the Arkona is characterized by a continuous belt of sand in which dunes are numerous. Within two miles of Geneva two other fragments of the lower beach are shown. West of Geneva, near the border of the sheet, a short segment of the higher level is indicated; and several more segments of this stage are shown south of the Nickle Plate railway between Ashtabula and Geneva.

Lake Warren

Throughout much of this sheet, the Warren consists of a single beach ridge, about 680 feet in altitude; locally, an earlier but temporary position of the shoreline registered low fragmentary ridges, as shown on the western side where two segments are mapped as details of the main beach ridge. Bordering the Warren beach, in this vicinity, for nearly a mile, is a low rather flat ridge which belongs to Lake Wayne. From this point to Geneva the highway continues to follow the Warren beach, but east of the Lake Shore railway, the beach lies south of the street, and consists of gravel capped with sand.

Eastward from Geneva the highway to Ashtabula follows the Warren beach ridge which consists of gravel and sand, the latter increasing relatively toward Ashtabula. The ridge is rarely over six feet high; in the vicinity of Ashtabula, and along Prospect street in the city, the outer slope of the beach appears to have been steepened by wave-cutting shortly before this lake stage ended.

From the corporation limits of Ashtabula east to the Pennsylvania railway, the beach ridge is just north of Prospect street; between the railway and the river, this street appears to follow the crest rather than the back slope of the beach; the water slope shows some effects of wave-cutting; scattered areas of sand, some distance, north, suggest barrier beaches and shoal deposits.

The Ashtabula River has cut a gap slightly wider than its gorge, in the beach, the course of which on either side of the river indicates the absence of any bay at this point in the Warren shoreline. East of the river the course of the shoreline is marked by the highway leading to Conneaut. The outer slope of the beach is quite steep; near the margin of the sheet, sand on the beach-crest has been drifted into dunes.

Lake Wayne

Lake Warren was preceded by Lake Wayne, the shoreline of which lies 20 feet below that of Lake Warren. The Wayne shoreline

in consequence of this submergence consists of detached portions of beach ridges, usually washed down into broad swells of clayey sand, separated by long flat stretches over which there is sometimes a coating of sand, the only suggestion of wave-work.

East of Ashtabula the Conneaut highway follows the beach of Lake Warren. Close to and paralleling its north slope are several stretches of sand, somewhat arched, which might be interpreted as barriers of the Warren stage; more likely, however, these belong to Lake Wayne. The sand when examined closely does not resemble the loose-textured and more-easily-poured Warren sand.

Westward from Ashtabula the Lake Shore and Michigan Southern railway parallels a sandy tract which is very uniform in surface features; only one ridge segment has been indicated on the map, and this swell may be entirely of wind, rather than wave, origin, though its position suggests a barrier relationship to the Wayne beach.

Within the city limits of Ashtabula is a deposit of sand which may belong to Lake Warren, that is, of barrier origin; but its flat surface and content of clay suggest a washed-down Wayne beach. Commencing about a mile west of the city, the Wayne shoreline appears in disconnected ridges, low and sandy, parallel to the highway. West of Saybrook, the shoreline segments lie a little farther north of the Warren beach. In Geneva the Wayne appears to lie between the Lake Shore railway and Main street which follows the Warren beach. Another Wayne segment, about a mile long, is noted west of Wheeler Creek.

Lake Lundy

Grassmere Stage. For a mile on the east side of the sheet the highway, which is just north of the Lake Shore and Michigan Southern railway, follows the Grassmere beach ridge which consists of sand, and in places stands 6 to 8 feet above the general level. No more evidence of this shoreline is found east of the Ashtabula River nor within the first mile west of the river; the absence of wave-deposited materials may be the result of stream action. Thence westward a broad belt of sand, with an occasional segment of beach ridge, characterizes the level of this lake stage. Throughout a distance of three miles north of Saybrook even segments of sand are wanting. Nearing Geneva, however, the sandy belt bears numerous stretches of broken beaches; in no case, save where wind action has operated, are these ridges over three or four feet high.

Elkton Stage. This lower level of Lundy Lake is locally well-developed on the Ashtabula sheet. Proceeding from the east side one is unable to find any evidence of the Elkton beach east of the Lake Shore Club which occupies a position a few rods back from the present shore of Lake Erie and about one-half mile east of the Ashtabula River harbor. Here the beach ridge, consisting of clean medium-sized gravel, is very typical in cross-section. West of the harbor the ridge lies south of the Lake Road, and is continuous for a mile; thence westward it bears south from the Lake Road for about one-half mile, and again turns north to within a few rods of the highway, terminating near Red Brook. The sandy content of this beach increases the farther it is traced west from the Harbor.

After leaving Red Brook, for an interval of a mile and a half one finds no definite evidence of a shoreline. About two and one-half miles northwest of Saybrook there is a distinct crook in the course of Indian Creek; this irregularity in the stream is probably due to the Elkton beach. East of the creek is a low sandy beach segment, about one-half mile long, but in the vicinity of the stream no distinct shoreline appears today. The best evidence, however, of the former existence of a beach at this vicinity is the elbow in the course of the stream. The highway west of the creek crosses a low ridge of barrier sand. Between Indian and Cowles Creeks only one short segment of beach was noticed. West of Cowles Creek a sandy ridge is easily traced. West of Wheeler Creek the Elkton, for some distance, has a very distinct development; the sand on the land-side shows evidence of spreading by the wind.

THE PROGRESS OF GEOLOGY DURING THE PERIOD 1891-1915[1]

Frank Carney

In every line of science some very important event may have culminated on a particular day. On the other hand, a twenty-five year interval may pass without recording a contribution of note, even though it were always possible to discern the highest merit; epoch making discoveries may not be recognized at once. Thus, as we members of the Ohio Academy of Science pass the first twenty-five year period of our history, and ask what has been accomplished in our individual fields of work, the answer may be sedately prosaic.

Pseudo-geologists. There was a time when one man knew as much as any other man about earth science, and home made geology was the only kind available. The output of this type of revelation has decreased relatively with the increase in the number of trained students, or of men with aptness for interpreting what they see. Nevertheless the last twenty-five years have recorded some extremely interesting specimens of pseudo-geology. The avenues of publication, which embrace a whole gamut of documents from the privately printed book to the widely read Sunday edition, give publicity to matter which finds no place in the documents of learned societies. Possibly we will always have the naive expounders of geological phenomena, men and women whose names may appear "often in paragraphs, seldom in monographs."

Pioneers in Geology. It has been the privilege of many of us to know a very few of these survivors from the early days of American geology, the versatile Patriarchs of a frontier stage. This type of teacher knew something of all sides of his study: as a chemist, he interpreted minerals from that point of view; he was a zoologist to the extent of knowing fossil forms as analogies or prototypes of living animals; he was a physiographer in recognizing the salient relationships between rock texture and structure and land forms; he was a geomorphologist because expected to account for the grosser anatomy

[1]Reprinted, with slight alterations, from the *Proceedings, Ohio Academy of Science*, vol. VI, part 5, 1916, pp. 299-308, an address read at the Quarter Centennial Anniversary of the Academy.

of the continents; he was a meteorologist since at that time no one else in the village communities or on the college faculties was thought to bear a closer relationship to the mysteries of the air; he was an anthropologist because fossils, hence all antiquities, belonged to his domain; and the public decreed that he was also an antiquarian. These men were promethean encyclopedias of facts, inspiring teachers, illuminating but unrecompensed prophets whose real compensation is the host of workers begot by their enthusiasm.

The sons of these pioneers, as is usual with the second generation, did not give disappointment by evincing greater wisdom than the fathers, and their grandsons feel no chagrin in not knowing completely any one of the numerous fields which the grandsires cultivated thoroughly. Thus has geology evolved specialists.

A comparison of the courses offered today and in the year 1890 by the Departments of Geology in our colleges and universities shows the results of specialization. No longer can the student listen to lectures on minerals, and mountain development, and mining, and paleontology, and petrography, given by the same man. The most modestly equipped university now has at least three groups in its geology courses; the more fully equipped have five or six groups. The tendency augurs further subdivision. It is not so long since the department of mineralogy did the work of the petrographer, but now our petrographers are splitting into several particular fields. In this subdivision of its work, geology and the other sciences accord with modern industry; and in the most highly organized industrial plants, the best machine does automatically just one thing. Possibly in the years to come, when all the little parcels of investigation have been thoroughly analyzed, the generations will begin to produce synthetically an end product that may bear some semblance to the pioneer in geology.

Text Books. The extensive geologic text of Eduard Suess, begun in the 80's, was completed a few years ago, not long before his death. This remarkable set of books has inspired emulation in several other countries. The comprehensive text of Geike in two volumes was very completely revised and republished in 1903. In this country a similar feat of scholarship has been accomplished by Chamberlin and Salisbury. It is doubtful whether we will have many more such texts. Geology as a science has become so subdivided, and so much detail worked out in each field, that a general

text book, to be complete, must be encyclopedic in size and would be little used except in libraries.

The last decade has witnessed the appearance of special books, each covering a particular field, as the dynamic, structural, tectonic, glacial, and paleontologic phases of the subject. Furthermore, special parts of these fields are beginning to have their individual manuals. This diversity of texts is to be expected as a result of the growing number of specialists in geology.

Periodicals. Twenty-five years ago, The American Geologist was the only American periodical in this field of science. In the year 1890, the Bulletin of the Geological Society of America began publication. Three years later the Journal of Geology was founded. In 1905, The American Geologist was incorporated with Economic Geology which first appeared in that year. The Bulletin of the Seismological Society of America dates from 1910. This large gain in the list of serials indicates an activity for which ample provision is not found in the publications of the federal and state surveys, or of learned societies.

United States Geological Survey. A national survey is a fair index of the status of geology in a country. Appropriations and men make a survey; an abundance of one can not at once offset a shortage of the other, but may tend to create an ample supply.

From 1890 to 1901 the lowest appropriation allowed the federal Survey any year was $494,640; the highest was $1,000,159.25; the average for the 12 years was $757,277.90. Since 1901, including 1916, the average annual appropriation was $1,544,048.33. In 1907 the irrigation work was withdrawn from the Survey, and in 1911 the Bureau of Mines was created relieving the Survey of certain technologic duties.

It is a matter of pride to all Americans that the United States Geological Survey now leads the nations in the quality of its topographic maps; but it is unfortunate that this work does not proceed more rapidly. If the rate of the last twenty-five years continues, nearly a century will pass before the map of our national area is completed. The general efficiency of its organization is also the envy of foreign workers. With us, as a general rule, politics, militarism, and geology mutually observe a decorous neutrality.

Progress in Economic Geology. In the early days of our state and federal surveys, the chief reason for their expenditure of public money was the securing of returns through the development of our

mineral resources. The results secured did not always satisfy the public. Consequently individuals and companies supported their own investigations. Later the surveys began to give more attention to economic minerals. The federal survey has become the chief authority on the mining and reduction of ores. Evidence of this leadership, is the fact that private corporations are drawing from the federal survey many of their highest salaried investigators.

The vastness of our mineral resources and the ease with which they are turned into wealth has encouraged careless and partial development. This falling short of possible accomplishment is keenly brought to our attention at the present time when the end results of certain hydrocarbon by-products, i. e., dyes, cannot be procured because Germany alone has carried such investigations to the highest industrial use. The same deficiency of development by Americans is also illustrated in the former exportation of radium minerals and other valuable ores which we preferred to sell raw. The present exigency in reference to dyes has aroused Americans, and should lead to a greater industrial independence; and the federal government, in co-operation with the American Radium Institute, an organization endowed for cancer investigation, is already successfully treating radium minerals and isolating the required radium salt. A further result of the present industrial condition in Europe is the hope that Americans may produce their own supply of potash salts and other ingredients in the manufacture of fertilizers; the federal survey is investigating the possibility of securing at least some of these supplies from our own minerals.

Bureau of Mines. The response of the government to the increasing need of assistance in developing and conserving our mineral resources is seen in the organization in 1911 of the Bureau of Mines. Previously this work was one of the lines of activity of the Geological Survey. In addition to investigating problems connected with the reduction of minerals and with non-wasteful methods of mining, this Bureau has attracted much attention through its efforts to avoid, and meliorate the disastrous effects of, mine accidents. Such work is conservation in the highest sense; it is much more excusable to waste minerals than men.

Alaska. In Alaska there is a larger percentage of government lands than in any other of the territories or states. In handling these lands the government can apply, usually without restraint, the most recent findings of its experts. Probably for this reason, the Geological

Survey has given special attention since 1896 to the mineral resources of Alaska, increasing the annual amount allowed for this study from $5,000 to $100,000. This field, therefore, offers the survey its freest opportunity for testing its best judgment on the development of mineral wealth. Complete harmony of opinion does not prevail in reference to the management of Alaska's mineral resources. The activity of private corporations in Alaska as well as the advice of experts acting for the government have led to contentions and much unpleasantness. Another generation will estimate more fairly these matters of dispute.

Mining Schools. The demand that college students might receive a training which would make them useful in mining operations led many years ago to the introduction of certain courses in mining, chiefly in technical institutions. Since then, departments of mining engineering have been established in other colleges. A later development is the founding of regular mining colleges. Within the last decade several large universities have organized schools of mining engineering, making use of courses already being offered and adding new courses to the several departments concerned. All of this development is indicative of the increasing demand for trained men in exploiting our mineral resources.

Work in Paleontology. This fundamental side of geology, oldest in popular interest, if not also in the development of the science, has made remarkable progress during the last twenty-five years. A measure of this progress is seen in the organization of the Paleontological Society in the year 1909, which works in co-operation with the Geological Society of America, of which, in reality, it is an out-growth.

The remarkable literature, both in volume and content, accumulated by paleontologists has necessitated the publishing of bibliographic indexes by the Federal Survey and the U. S. National Museum. The high standard of publications, particularly in the great expense required for the plates produced, by both the Federal and State Surveys, attests the sustained interest of the public, and the productiveness of the workers, in this field of geology.

Geological Survey of Ohio. The formation of the Third Survey of this state was almost coincident with the founding of the Ohio Academy of Science. When J. S. Newberry withdrew from the office of state geologist, the survey activities were placed in the hands of Edward Orton, Sr., who completed the work then under way, that is

volumes V and VI and "A Preliminary Report on Petroleum and Natural Gas," embracing in all 1931 pages, before proceeding with his own plans as state geologist. Professor Orton in addition to a report on Botany and another on Archeology, published about 1200 pages, divided almost equally between economic subjects, and stratigraphy and paleontology.

The Fourth Survey was formed in 1899 with Professor Edward Orton, Jr., as state geologist. Under his direction the survey published 1825 pages; 79.8% was devoted to economic geology, and of the remainder, 332 pages consisted of a bibliography of geologic papers relating to Ohio, and 36 pages were devoted to the "Nomenclature of geological formations."

In 1906 Professor John Adams Bownocker was appointed State Geologist. During the nine years to date, Professor Bownocker, in addition to a new geological map of Ohio, has published 2872 pages, apportioned as follows: historic, 45.9%; the economic, 51.9%; the remainder, physiographic. It should be noted, however, that other physiographic problems have been under investigation for several years. Under no other State Geologist have the activities of the Survey been more generally distributed among different phases of geology.

A New World Map. Federal geological organizations in the various countries have made it possible to consummate a proposal of the geographers. At a meeting of the Fifth International Geographical Congress at Bern, in 1891, a movement was initiated for the production of a standardized world map, on a scale of one to one million, i. e., about 15.78 statute miles to the inch. This was an optimistic proposal, the realization of which would require the cooperative interest of the several governments which are making maps of their territory. Slowly the idea took root; France, Germany, and England began to publish sheets on this scale. Following the Eighth Geographical Congress, which met in this country in 1904, our government through the Topographic Branch of the Geological Survey, commenced the issue of such sheets.

Uniformity in other respects than scale was insured by an agreement made at the Ninth Congress, which assembled in 1908 at Geneva, to use the polyconic projection, to reckon longitude from Greenwich, to have each sheet cover 4° of latitude and 6° of longitude, and to express altitude in intervals of 200 meters, though variations may be used in very flat and very mountainous regions.

This is a noteworthy example of international co-operation in science. Having a standard map of definite scale and projection, all the continents may be represented in their relative size; and from such standard maps larger or smaller ones may be drawn, giving a true representation, because the land areas will be shown in the same proportion.

Climate of the Geologic Past. Ecology teaches us today's correlation between organisms and their environment. We expect the most successful functioning of life forms only in a suitable combination of light, heat, moisture, food, and neighbors, a favorable habitat. In a dim way, students long ago recognized in the fossil record anomalies when referred to the present physical conditions of the fossil's geographical location. It was inferred, therefore, that in the progress of geologic time there have come changes in climate, or at least in the distribution of mean annual temperature, in particular parts of the earth's surface. A similar inference has been drawn from wide-spread glaciation. Both deductions are rather broad generalizations.

Since 1890 there has been a tendency in these matters to seek the concrete and specific. Wherever possible more exact methods have been applied to the hazy interpretations of the past. This application is limited, for the present at least, to the recent geologic past, and the corroboration of human history, wherever possible, adds welcome conviction. Thus is the field exceedingly limited. However, encouraging results have been secured particularly through the work of Ellsworth Huntington in a study of strand lines, and of the growth made by very old trees, the sequoias; the latter respond to, and, in their rings of seasonal growth, register the conditions of moisture; the former register variations in the level of water bodies in inland basins. Quite recently, Mr. Huntington is attempting to correlate the precipitates of desiccating water with the other two lines of evidence.

This type of investigation is producing results which accord with the deductions made by the paleontologist from the expanding, dwarfing, or disappearance of faunas; it throws light on the origin of gypsum and other locally deposited salts; and helps to elucidate several stratigraphic features.

The Age of the Earth. When one arrays the estimates of this sphere's antiquity, made by workers in various phases of science, he must conclude that mother earth is either a coy maiden, an indifferent

matron, or a gibbering old woman. The margin of safety in these guesses is about one billion years.

In 1862 Lord Kelvin, studying the thermal conductivity of the sphere, decided that the earth is at least 20 million and not over 400 million years old. After an interval of 35 years he amended these figures somewhat and stated, in concurrence with Clarence King's assertion, that about 24 million years ago the earth was a molten mass.

Sir George Darwin in 1886 had urged the wisdom of considering "Theories which appear to demand longer periods of time than those which now appear allowable." Ten years ago he suggested again that the physicists may be in error in computing the age of the earth, and said: "The scale of geological rime remains in great measure unknown."

From the thickness of sediments, and the rate at which rivers are making deposits, Charles D. Walcott in 1893 reckoned the lapse of time since the beginning of the Archean to be 90 million years.

Professor John Joly in 1899, from computations of the quantity of sodium in the oceans and their annual accession of sodium, stated the probable age of the earth to be from 90 to 100 million years.

Students of biology have preferred a great length of time for the complex results of evolution. The estimates made by physicists, chemists, and some geologists appear inadequate to them.

Since the discovery of radium, and a more general investigation of radio-active minerals and derivatives from radium, the evolutionists have taken hope. No line of investigation has been so profligate with time as that concerning radio-activity. John Allen Harker, the British physicist, says, "a study of the various radioactive elements contained in minerals and rocks has shown that it is possible, in certain favorable cases, to calculate directly their ages in years." Thus calculated, the Archean rocks are from one billion to one billion, six hundred million years old.

Over a hundred years ago, Hutton, speaking as do the poets and the prophets in science, asserted that geologic time had "no vestige of a beginning, no prospect of an end."

Theories of Earth-Origin. Twenty-five years ago one seldom heard any question raised about the satisfactoriness of the nebular hypothesis. More recently certain variations in this hypothesis have been proposed, but the fundamentals of the Laplacian theory have place in all these restatements. Necessarily, modifications should

follow upon the findings of the spectroscope and photograph-attachments of the large telescopes, instruments that were scarcely dreamed of in the day of the French savant.

Among the contributions made to geology since the organization of this Academy none is greater than that of T. C. Chamberlin arising from his critical examination of the various hypotheses for the origin of the solar system. Chamberlin's "Planetesimal Hypothesis," in the estimation of one who has studied his several papers from the related series beginning with, "A Group of Hypotheses Bearing on Climatic Changes" (*Journal of Geology*, Vol. V (1897), pp. 653; Vol. VII, pp. 545-584, 667-685, 751-787) is largely a by-product of his studies in reference to the origin of the atmosphere. This fact illustrates how interwoven and interdependent are the various phases of truth.

The simplicity of the Laplacian theory, and its accordance with all that was then known about the planetary system, the vastness of its generalizations, and the meager knowledge of the fundamentals in any theory of earth-origin, led to its immediate and almost universal acceptance. So long has this theory been taught that the idea of a once molten sphere has become a premise, almost an axiom, and is made fundamental in explaining mountains, volcanic activity, and in petrographical studies. The dissent from its teachings is still very local, as is a studious interest in any alternative theory. Conservatism is the armor, as well as the embalming fluid, of science.

That the planetesimal theory as now stated, or slightly modified, will in time be generally accepted, is the belief of most men who have made themselves acquainted with the basis of study from which this theory developed. In our generation no greater contribution has been made to theoretical geology.